Gov. Doc.
Ont.
L
Ontario Legislative Assembly

SESSIONAL PAPERS

VOL. LIV.—PART II.

THIRD SESSION

OF THE

FIFTEENTH LEGISLATURE

OF THE

PROVINCE OF ONTARIO

SESSION 1922

194396
17.2.25

TORONTO:
Printed by CLARKSON W. JAMES, Printer to the King's Most Excellent Majesty
1923

PRINTED BY
RYERSON PRESS

LIST OF SESSIONAL PAPERS

Presented to the House during the Session

Title	No.	Remarks
Accounts, Public, 1921	1	*Printed.*
Agricultural College, Report	30	"
Agricultural and Experimental Union Report	32	"
Agricultural Development Report	97	*Not Printed.*
Agricultural Societies, Report	43	*Printed.*
Agriculture, Department of	29	"
Archives, Report	52	*Not Printed.*
Auditor, Provincial, Report	54	*Printed.*
Backus, E. W., Correspondence, Lake of the Woods, etc.	76,78	*Not Printed.*
Bee-Keepers Association, Report	37	*Printed.*
Births, Marriages and Deaths, Report	20	"
Blue Sky Legislation, Report	67	"
Brantford Commission, Report	74	*Not Printed.*
Brantford, administration of Justice in, or County of Brant	75	"
Canada Roads Act, correspondence	77	*Not Printed.*
Chatham, Report of Commission *re* seizure of whiskey at	70	"
Children, Neglected, Report	27	"
Civil Service Commission, Report	91	*Printed.*
Dairymen's Association, Report	38	*Printed.*
Division Courts Inspector, Report	5	"
Education, Report	17	*Printed.*
Education, Orders-in-Council	56	*Not Printed.*
Elections, by, Returns from Records	51	*Printed.*
Entomological Society, Report	36	"
Estimates	2	"
Extra-mural Employment Commission, Report	60	"
Friendly Societies, Report	11	*Printed.*
Fruit Growers' Associations, Report	44	"
Game and Fisheries, Report	14	*Printed.*
Game and Fisheries Act, fines, etc., under	72	*Not Printed.*
Gaols and Prisons, Report	26	*Printed.*
Gregory Commission	82	*Not Printed.*

TITLE	No.	REMARKS
Harding, R. T., correspondence *re* Hourigan & Co.	88	*Not Printed.*
Hastings, Magistrate, correspondence *re* dismissal of	99	*Not Printed.*
Health, Report of Board of	21	*Printed.*
Health, Regulations *re* Lumber Camps	80	*Printed.*
Heenan, Peter, correspondence *re* appointment of	101	*Not Printed.*
Highway Improvement Fund, sums credited to	92	*Not Printed.*
Highway Improvement Fund, sums credited to	94	*Not Printed.*
Highway construction, contribution under Canada Roads Act	77	*Not Printed.*
Horticultural Societies, Report	42	*Printed.*
Hospitals and Charities, Report	25	*Printed.*
Hospitals and Charities, Orders-in-Council	98	*Not Printed*
Hurdman Scale, Report	83	*Not Printed*
Hydro-Electric Railway Commission, Report	24	*Printed.*
Hydro-Electric Power Commission, Report	49	*Printed.*
Hydro-Radial Commission, correspondence *re* remuneration	100	*Not Printed*
Insane, Feebleminded and Epileptic, Report	22	*Printed.*
Insurance, Report	10	*Printed.*
Keewatin Lumber Company, timber removed by	86	*Not Printed*
Kingston Highway, work done on, etc.	58	*Not Printed*
Labour Department, Report	16	*Printed.*
Lake of the Woods, correspondence, etc.	76	*Not Printed*
Lake of the Woods, correspondence, etc.	78	*Not Printed*
Lands and Forests Department, Report	3	*Printed.*
Land Titles Act, Operation of	69	*Printed.*
Lefevre, Constable, correspondence	87	*Not Printed*
Legal Offices, Report	6	*Printed.*
Librarian, Report	53	*Not Printed*
License Commissioners, applications to, for remission of fines or sentences, etc.	81	*Not Printed*
Live Stock Branch, Report	39	*Printed.*
Loan Corporations, Report	12	*Printed.*
Lumber Camps, Regulations	80	*Printed.*
Mines Department, Report	4	*Printed.*
Minimum Wage Board, Report	73	*Printed.*
Mothers' Allowances, Commission Report	89	*Printed.*
Municipal Affairs, Report	47	*Printed.*
Municipal Auditor, Report	8	*Printed.*
Nipigon and Pic River, agreement *re* lease	63	*Printed.*
Ontario Agricultural College, Report	30	*Printed.*

TITLE	NO.	REMARKS
Ontario Athletic Commission, Report	85	*Not Printed.*
Ontario Railway and Municipal Board, Report	50	*Printed.*
Ontario Temperance Act, Report	28	*Printed.*
Ontario Temperance Act, correspondence *re* penalties, etc.	95	*Not Printed.*
Parole Board of, Report	59	*Printed.*
Police Court, Toronto, Report	61	*Not Printed.*
Police Court, Toronto, Report *re* charges	64	*Not Printed.*
Presbyterian Manse, Vernon	71	“
Prisons and Reformatories, Report	26	*Printed.*
Public Accounts, 1921	1	*Printed.*
Public Highways, Report	15	*Printed.*
Public Service Superannuation Board, Report	79	*Printed.*
Public Works Department, Report	13	“
Queen Victoria Niagara Falls Park, Report	9	*Printed.*
Queenston-Chippawa Power Development, Commission to W. D. Gregory	82	*Not Printed.*
Registry Offices, Report	7	*Printed.*
Rural Public and Separate Schools, Legislative grants to	96	*Printed.*
Secretary and Registrar, Report	19	*Printed.*
Sheriffs, Report of Commission	57	*Printed.*
Shevlin-Clarke Company, Ltd., letters and documents	62	*Not Printed.*
Shevlin-Clarke Company, agreement *re* settlement	66	*Not Printed.*
Soldiers' Aid Commission, Report	93	*Not Printed.*
Statistics Branch, Report	46	*Printed.*
Statutes, Distribution of	68	*Not Printed.*
Temiskaming and N. O. Railway, Report	48	*Printed.*
Timber Limits offered for sale	84	*Not Printed*
Toronto and Hamilton Highway Com., correspondence	90	*Not Printed*
Toronto Police Court, Reports	61, 64	*Not Printed*
Toronto University, Report	18	*Printed.*
Vegetable Growers Association, Report	34	*Printed.*
Vernon Presbyterian Manse, correspondence	71	*Not Printed*
Whiskey Seizure, Report of Commission	70	*Not Printed*
Women's Institutes, Report	41	*Printed.*
Workmen's Compensation Board, Report	55	“
York Registry Office, Report of Commission	65	*Not Printed.*

LIST OF SESSIONAL PAPERS

Arranged in numerical order, with their titles at full length; the dates when presented to the Legislature; the name of the Member who moved the same, and whether ordered to be printed or not.

CONTENTS OF PART I.

No. **1** Public Accounts of the Province for the year ending 31st October, 1921. Presented to the Legislature, 14th March, 1922. *Printed.*

No. **2** Estimates—Supplementary, *re* Queenston-Chippawa Development. Presented to the Legislature, 3rd March, 1922. *Not Printed.* Supplementary Estimates for the service of the Province for the year ending 31st October, 1922. Presented to the Legislature, 16th March, 1922. *Printed.* Further Supplementary Estimates. Presented to the Legislature, 26th May, 1922. *Printed.* Estimates for the year ending 31st October, 1923. Presented to the Legislature, 31st May, 1922. *Printed.*

CONTENTS OF PART II.

No. **3** Report of Minister of Lands and Forests for the year 1921. Presented to the Legislature, 8th June, 1922. *Printed.*

No. **4** Report of the Minister of Mines for the year 1921. Presented to the Legislature, 2nd May, 1922. *Printed.*

CONTENTS OF PART III.

No. **5** Report of the Inspector of Division Courts for the year 1921. Presented to the Legislature, 5th April, 1922. *Printed. See Part* 3, 1921 *Session.*

No. **6** Report of the Inspector of Legal Offices for the year 1921. Presented to the Legislature, 6th April, 1922. *Printed.*

No. **7** Report of the Inspector of Registry Offices for the year 1921. Presented to the Legislature, 6th April, 1922. *Printed.*

No. **8** Report of the Provincial Municipal Auditor for the year 1921. Presented to the Legislature, 29th May, 1922. *Printed.*

No. **9** Report of the Commissioners for Queen Victoria Niagara Falls Park for the year 1921. Presented to the Legislature, 9th June, 1922. *Printed.*

No. **10** Report of the Superintendents of Insurance for the year 1921. Presented to the Legislature, 6th April, 1922. *Printed.*

No. **11** Report of the Registrar of Friendly Societies' Transactions for the year 1921. Presented to the Legislature, 6th April, 1922. *Printed.*

No. **12** Report of the Registrar of Loan Corporations for the year 1921. Presented to the Legislature, 6th April, 1922. *Printed.*

CONTENTS OF PART IV.

No. **13** Report of the Minister of Public Works for the year 1921. Presented to the Legislature, 22nd March, 1922. *Printed.*

No. **14** Report of the Game and Fisheries Department for the year 1921. Presented to the Legislature, 8th June, 1922. *Printed.*

No. **15** Report on Highway Improvement for the year 1921. Presented to the Legislature, 30th May, 1922. *Printed.*

No. **16** Report of the Department of Labour for the year 1921. Presented to the Legislature, 1st June, 1922. *Printed.*

No. **17** Report of the Minister of Education for the year 1921. Presented to the Legislature, 29th May, 1922. *Printed.*

No. **18** Report of the Board of Governors of the University of Toronto for the year ending 30th June, 1921. Presented to the Legislature 22nd March, 1922. *Printed.*

CONTENTS OF PART V.

No. **19** Report of the Secretary and Registrar of the Province for the year 1921. Presented to the Legislature, 7th June, 1922. *Printed.*

No. **20** Report of the Registrar General relating to the registration of Births, Marriages and Deaths. Presented to the Legislature, 8th June, 1922. *Printed.*

No. **21** Report of the Provincial Board of Health for the year 1921. Presented to the Legislature, 1st June, 1922. *Printed.*

No. **22** Report upon the Ontario Hospitals for Insane, Feeble-minded and Epileptic for the year, 1921. Presented to the Legislature, 9th June, 1922. *Printed.*

No. **23** Report on Hospitals for Idiots. *Included in No. 22.*

No. **24** Report of Hydro-Electric Railway Commission. Presented to the Legislature, 24th February, 1922. *Printed.*

No. **25** Report upon Hospitals and Charitable Institutions for the year 1921. Presented to the Legislature, 9th June, 1922. *Printed.*

No. **26** Report upon the Prisons and Reformatories of the Province for the year 1921. Presented to the Legislature, 8th June, 1922. *Printed.*

No. **27** Report upon Neglected and Dependent Children for the year 1921. Presented to the Legislature, 8th June, 1922. *Not Printed.*

No. **28** Report upon the working of the Ontario Temperance Act for the year 1921. Presented to the Legislature, 8th June, 1922. *Printed.*

CONTENTS OF PART VI.

No. **29** Report of the Minister of Agriculture for the year 1921. Presented to the Legislature, 1st June, 1922. *Printed.*

No. **30** Report of the Ontario Agricultural College and Experimental Farm for the year 1921. Presented to the Legislature, 31st May, 1922. *Printed.*

No. **31** Report of the Veterinary College. *Not presented.*

No. **32** Report of the Agricultural and Experimental Union for the year 1921. Presented to the Legislature, 15th May, 1922. *Printed.*

No. **33** Report of the Stallion Enrolment Board. *Not presented.* (*Printed.*)

No. **34** Report of the Vegetable Growers Association for the year 1921. Presented to the Legislature, 1st June, 1922. *Printed.*

No. **35** Report of the Corn Growers Association. *Not presented.*

No. **36** Report of the Entomological Society for the year 1921. Presented to the Legislature, 1st June, 1922. *Printed.*

No. **37** Report of the Bee-Keepers Association for the year 1921. Presented to the Legislature, 1st June, 1922. *Printed.*

No. **38** Report of the Dairymen's Association for the year 1921. Presented to the Legislature, 1st June, 1922. *Printed. See Sessional vol. for* 1923.

No. **39** Report of the Live Stock Branch of the Department of Agriculture for the year 1921. Presented to the Legislature, 1st June, 1922. *Printed.*

No. **40** Report of the Housing Commission. *Not presented.*

No. **41** Report of the Women's Institutes of the Province for the year 1921. Presented to the Legislature, 1st June, 1922. *Printed.*

No. **42** Report of the Horticultural Societies for the year 1921. Presented to the Legislature, 1st June, 1922. *Printed.*

No. **43** Report of the Agricultural Societies and of the Convention of the Association of Fairs and Exhibitions for the year 1921. Presented to the Legislature, 31st May, 1922. *Printed.*

No. **44** Report of the Fruit Growers' Association for the year 1921. Presented to the Legislature, 31st May, 1922. *Printed.*

No. **45** Report of the Vineland Experimental Station. *Not Presented.*

No. **46** Report of the Statistics Branch of the Department of Agriculture for the year 1921. Presented to the Legislature, 31st May, 1922. *Printed.*

CONTENTS OF PART VII.

No. **47** Report of the Bureau of Municipal Affairs for the year 1921. Presented to the Legislature, 12th April, 1922. *Printed.*

No. **48** Report of the Temiskaming and Northern Ontario Railway Commission for the year 1921. Presented to the Legislature, 22nd May, 1922. *Printed.*

No. **49** Report of the Hydro-Electric Power Commission for the year ending, 31st October, 1921. Presented to the Legislature, 30th May, 1922. *Printed.*

No. **50** Report of the Ontario Railway and Municipal Board for the year 1921. Presented to the Legislature, 12th May, 1922. *Printed.*

CONTENTS OF PART VIII.

No. **51** Return from the Records of the By-Elections to the Legislative Assembly held on the 19th day of December, 1921, and the 6th day of February, 1922, showing:—

(1) The number of Votes Polled for each Candidate in each Electoral District in which there was a contest; (2) The majority whereby each successful Candidate was returned; (3) The total number of Votes polled; (4) The number of Votes remaining unpolled; (5) The number of names on the Polling Lists; (6) The number of Ballot Papers sent out to each Polling Place; (7) The Used Ballot Papers; (8) The Unused Ballot Papers; (9) The Rejected Ballot Papers; (10) The Cancelled Ballot Papers; (11) The Declined Ballot Papers; (12) The Ballot Papers taken from Polling Places; (13) A General Summary of Votes cast in each Electoral District. Presented to the Legislature, 21st February, 1922. *Printed.*

No. **52** Report of the Bureau of Archives for the year 1921. Presented to the Legislature, 20th April, 1922. *Not Printed.*

No. **53** Report of the Librarian on the state of the Library. Presented to the Legislature, 1st May, 1922. *Not Printed.*

No. **54** Report of the Provincial Auditor for the year 1920-21. Presented to the Legislature, 20th April, 1922. *Printed.*

No. **55** Report of the Workmen's Compensation Board for the year 1921. Presented to the Legislature, 1st June, 1922. *Printed.*

No. **56** Copies of Regulations and Orders-in-Council made under the authority of the Department of Education or of the Acts relating to Public Schools, Separate Schools or High Schools. Presented to the Legislature, 22nd February, 14th March, 21st March, 5th April, 12th April, 25th April, 11th May, 29th May and 9th June, 1922. *Not Printed.*

No. **57** Interim Report of the Commission respecting Sheriffs appointed to inquire, consider and report upon best mode of selecting and remunerating Sheriffs, etc., etc. Presented to the Legislature, 24th February, 1922. *Printed.*

No. **58** Return to an Order of the House of the Twenty-fourth day of February, 1922, for a Return showing—1. The total cost as shown by the records in the Department of Highways of the work on the Kingston Highway at the east end of the Village of Pickering in the summer of 1921, where the highway was lowered almost to the level of the highway before construction work commenced—showing (*a*) Cost of excavation in summer of 1921; (*b*) Cost of surfacing road after excavation of 1921; (*c*) Total cost of all work done by reason of change in level of road in summer of 1921. 2. The original cost of filling the hollow when the road was originally built. 3. The original cost of surfacing the portion which was broken up in the summer of 1921. 4. By whose orders the change in the surface of the road was made in the summer of 1921. Presented to the Legislature, 24th February, 1922. *Mr. Sinclair. Not Printed.*

No. **59** Report of the Ontario Board of Parole for the year ending 31st October, 1921. *Printed.*

No. **60** Report of the Commission under the Extra-Mural Employment of Sentenced Persons Act, for 1921. Presented to the Legislature, 28th February, 1922. *Printed.*

No. **61** Interim Report of the Public Service Commission, respecting the Toronto Police Court. Presented to the Legislature, 28th February, 1922. *Not Printed.*

No. **62** Letters and Documents in the matter of the Shevlin-Clarke Company, Limited. Presented to the Legislature, 7th March, 1922. *Not Printed.*

No. **63** An Agreement made on the Ninth day of February, one thousand nine hundred and twenty-two, between His Majesty, represented by the Honourable the Minister of Lands and Forests for the Province of Ontario, hereinafter called the Government, of the first part, and Lewis L. Alstead, Esquire, of the City of Milwaukee, in the State of Wisconsin, and George A. Seaman, Esquire, of the City of Chicago, in the State of Illinois, hereinafter called the Grantees, respecting a lease, or leases, of Water Power on Nipigon and Pic River. Presented to the Legislature, 8th March, 1922. *Not Printed.*

No. **64** Report of the Commission appointed to conduct an enquiry into the truth or falsity of charges relating to Toronto Police Court, etc. Presented to the Legislature, 14th March, 1922. *Not Printed.*

No. **65** Interim Report of the Public Service Commission respecting the Registry Office of the County of York. Presented to the Legislature, 16th March, 1922. *Printed.*

No. **66** Agreement in the matter of settlement of suits of the Shevlin-Clarke Company, Limited. Presented to the Legislature, 16th March, 1922. *Not Printed.*

No. **67** Report upon Blue Sky Legislation. Presented to the Legislature, 20th March, 1922. *Printed.*

No. **68** Statement on Distribution of Revised and Sessional Statutes. Presented to the Legislature, 21st March, 1922. *Not Printed.*

No. **69** Interim Report of the Public Service Commission, on the operation of Land Titles Act in Northern Ontario. Presented to the Legislature, 21st March, 1922. *Printed.*

No. **70** Report of the Commission to make inquiries and report upon all matters and things connected with or relative or incidental to the seizure on or about the 21st of April, 1920, of a car of whiskey at the City of Chatham, etc., etc. Presented to the Legislature, 22nd March, 1922. *Not Printed.*

No. **71** Return to an Order of the House of 15th March, 1922, That there be laid before this House a return of copies of all documents, maps, correspondence and papers dealing with the purchase, expropriation or acquiring of a certain property occupied as the Presbyterian Manse at the Village of Vernon, in the County of Carleton, at the Department of Highways, or any official thereof. Presented to the Legislature, 22nd March, 1922. *Mr. Ferguson. Not Printed.*

No. **72** Return to an Order of the House of 28th February, 1921, That there be laid before this house a Return showing:—1. All fines and confiscations of property under The Game and Fisheries Act for each of the years 1916-17-18-19-20, imposed by game wardens, overseers or other representatives of the Department. 2. The number of such cases brought before a Magistrate of which there is any record for each year as above, and the numbers of recorded convictions. 3. The amounts for each year received by the Government and the amounts paid each year to informers. 4. Copies of instructions issued to game wardens, overseers or other representatives from time to time during the period 1912-20, dealing with the method of levying fines and directing seizure of property. Presented to the Legislature, 22nd March, 1922. *Mr. Hall. Not Printed.*

No. **73** Report of the Minimum Wage Board for the year 1921. Presented to the Legislature, 23rd March, 1922. *Printed.*

No. **74** Report of the Commission to investigate the Organization, Discipline, Administration and Efficiency of the Police Court of the City of Brantford. Presented to the Legislature, 5th April, 1922. *Not Printed.*

No. **75** Return to an Order of the House of Sixth of March, 1922, That there be laid before this House, a Return of copies of all correspondence and other documents between the Attorney-General's Department, the Ontario License Board, the Provincial Police Department, or Provincial Secretary's Department and any person or persons in Brantford having to do with the administration of justice for the City of Brantford or County of Brant since October 20th, 1919, to date. Presented to the Legislature, 7th April, 1922. *Mr. MacBride. Not Printed.*

No. **76** Return to an Order of the House of 30th April, 1921, That there be laid before the House a return of all copies of all correspondence between the Minister of Lands and Forests, the Prime Minister or any member of the Government, and E.W. Backus, or any other company, firms, or person, together with all estimates, reports, advertisements, conditions of sale, tenders, agreements, maps, documents and papers of every kind and nature relating to:—1. The Lake of the Woods pulp concession. 2. The White Dog Rapids Water Power, or any other water power in the District of Kenora. 3. The recent sale of pulp wood and timber on the English River concession. Presented to the Legislature, 10th April, 1922. *Mr. Ferguson. Not Printed.*

No. **77** Return to an Order of the House of 30th April, 1921, That there be laid before the House a Return of copies of all correspondence, papers, plans, reports and documents between the Minister of and the Federal Government and any Minister or official thereof, Highways, or any member of the Government or any official thereof, with reference to contribution under The Canada Roads Act towards the construction of Highways in Ontario. Presented to the Legislature, 10th April, 1922. *Mr. Henry. Not Printed.*

No. **78** Return to an Order of the House of 10th March, 1922, That there be laid before this House, a return of copies of all correspondence between the Minister of Lands and Forests, the Prime Minister, the Attorney-General, or any Member of the Government and E. W. Backus or any person on his behalf or any other company, firm or person, together with all estimates, reports, advertisements, conditions of sale, tenders, agreements, maps, documents, memoranda and papers of every kind and nature relating to (1) The Lake of the Woods pulp concession; (2) The White Dog Rapids water power or any other water power in Ontario; (3) The English River Pulp concession; (4) The Keewatin Lumber Company; (5) The Keewatin Power Company. Presented to the Legislature, 18th April, 1922. *Mr. Ferguson. Not Printed.*

No. **79** Report of the Public Service Superannuation Board for the year 1921. Presented to the Legislature, 19th April, 1922. *Printed.*

No. **80** Regulations of the Provincial Board of Health for sanitary control of Lumber, Timber and Mining Camps. Presented to the Legislature, 19th April, 1922. *Printed for distribution.*

No. **81** Return to an Order of the House of 29th March, 1921, That there be laid before the House a Return showing: 1. What is the number of applications to the Board of License Commissioners, or any Commissioner, Official or Minister for the remission of fines or sentences under the O.T.A. in regard to which the member for South-East Toronto (Seat "B") acted personally or was interested professionally. 2. (*a*) What is the number of such applications favourably considered; (*b*) Rejected. 3. (*a*) What is the total sum of fines under the O.T.A. remitted in regard to which the member for South-East Toronto (Seat "B") acted personally or was interested professionally; (*b*) What is the aggregate number of fines remitted from sentences imposed under the O.T.A. in regard to which the member for South-East Toronto (Seat "B") acted personally or was interested professionally Presented to the Legislature, 19th April, 1922. *Mr. Pinard. Not Printed.*

No. **82** Copy of Commission issued to Walter Dymond Gregory, *et al* to inquire into and report upon the estimates and other matters relating to the Queenston-Chippawa Power Development in pursuance of Order-in-Council, dated 13th April, 1922, thereto annexed. Presented to the Legislature, 19th April, 1922. *Not Printed.*

No. **83** Return to an Order of the House of 29th April, 1921, That there be laid before this House, a Return of the Report of the officer, or person, who has been conducting a scale of the logs and mill-cut at twenty-six lumber mills of Ontario throughout the sawing season of 1920. and which the Minister of Lands and Forests has reported to the House is now in his possession, together with the data on which the Report was based and all correspondence in connection therewith. Presented to the Legislature, 20th April, 1922. *Mr. McCrea. Not Printed.*

No. **84** Return to an Order of the House of 21st April, 1922, That there be laid before this House, a Return showing how many timber limits have been offered for sale since December 1st, 1919, and where situated. 2. Were they all sold by tender. 3. How long was each sale advertised. 4. The date of sale, area and price paid. 5. How many tenders were received in each case. 6. The name of the successful tenderer. Presented to the Legislature. 24th April, 1922. *Mr. McCrea. Not Printed.*

No. **85** Report and Statement of the Ontario Athletic Commission and of Auditor, for the year 1921. Presented to the Legislature, 25th April, 1922. *Not Printed.*

No. **86** Return to an Order of the House of 26th April, 1922, That there be laid before this House, a return showing the quantity of timber removed by the Keewatin Lumber Company in the District of Kenora each year during its cutting operations upon Berths S2, S3, S4, 3, 4, 6, 7, 10, 12, G9 and G10, 21 and 20. Presented to the Legislature, 28th April, 1922. *Mr. Mathieu. Not Printed.*

No. **87** Return to an Order of the House of 15th March, 1922, That there be laid before this House a Return of copies of all letters, telegrams or other correspondence during the year 1921, between any Minister of the Government or of any Member or Officer of the Ontario License Commission with any person or Corporation relating to the charges laid against Constable Lefevre, Provincial Police Force, and Constables Fleming, McKenzie and Michaud, the North Bay Police Force. Presented to the Legislature, 28th April, 1922. *Mr. Stover. Not Printed.*

No. **88** Return to an Order of the House of April 29th, 1921. That there be laid before this House, a return of copies of all Correspondence between R. T. Harding and the Honourable the Attorney-General, or any other Minister of the Crown, or any Officer of the Government since March 1st, 1921, with reference to a certain account for $500 rendered James Hourigan & Co. by the said R. T. Harding, and also copies of all letters from Crown Timber Agent Wylie since 1st June, 1920, referring to the settlement with James Hourigan & Co. for $12,600. Presented to the Legislature, 1st May, 1922. *Mr. Hill. Not Printed.*

No. **89** Report of the Mothers' Allowances Commission for the year 1921. Presented to the Legislature, 3rd May, 1922. *Printed.*

No. **90** Return to an order of the House of 12th April, 1922. That there be laid before this House, a Return of all copies of all correspondence, memoranda and reports between the Toronto and Hamilton Highway Commission and the Minister of Public Works or any member of the Government since November 15th, 1919. Presented to the Legislature, 11th May, 1922. *Mr. Henry. Not Printed.*

No. **91** Report of the Ontario Civil Service Commissioner for the year 1921. Presented to the Legislature, 12th May, 1922. *Printed.*

No. **92** Statement showing sums credited to The Highway Improvement Fund and all payments chargeable thereto as of October 31st, 1921. Presented to the Legislature, 12th May, 1922. *Not Printed.*

No. **93** Report of the Soldiers' Aid Commission of Ontario for the year 1921. Presented to the Legislature, 16th May, 1922. *Not Printed.*

No. **94** Statements showing all sums credited to the Highway Improvement Fund and all payments chargeable thereto for the fiscal years ending October 31st, 1920, and 1921, respectively. Presented to the Legislature, 23rd May, 1922. *Not Printed.*

No. **95** Return to an Order of the House of 9th February, 1921, That there be laid before this House, a Return of copies of all letters of instruction or other correspondence from the Attorney-General or any of the members of the Government, or Officials, addressed to any Police Magistrates or Crown Attorneys in the Province of Ontario; and any communications or letters in reply thereto relating to the imposition of penalties, or the trial of cases, and their disposition under The Ontario Temperance Act and amendments thereto. Presented to the Legislature, 30th May, 1922. *Mr. Dewart. Not Printed.*

No. **96** Return to an Order of the House of 25th May, 1922, that there be laid before this House, a Return showing (1) What Legislative Grants were earned in each of the years 1920 and 1921 by (*a*) Rural Public Schools, (*b*) Rural Separate Schools, (2) What was the actual amount paid to each Rural Public and Separate School for the said years. Presented to the Legislature, 6th June, 1922. *Mr. Cooke. Printed.*

No. **97** Report of the Agricultural Development Board for the year 1921. Presented to the Legislature, 8th June, 1922. *Not Printed.*

No. **98** Copies of Order-in-Council designating, pursuant to section 14 of the Hospitals and Charitable Institutions Act, Hospitals, Refuges, Orphanages and Infants' Homes to which aid may be granted. Presented to the Legislature, 8th June, 1922. *Not Printed.*

No. **99**	Return to an Order of the House of 29th April, 1921, That there be laid before this House, a Return of copies of all correspondence, reports and documents, relating to the dismissal of Magistrate Hastings, of Dunnville. Presented to the Legislature, 9th June, 1922. *Mr. Price. Not Printed.*
No. **100**	Return to an Order of the House of the 20th March, 1922, that there be laid before the House a Return of copies of all correspondence between any Minister of the Crown and any member of the Hydro-Radial Commission in connection and dealing with accounts for remuneration of services by each and every member of the Commission whether such accounts were paid in full for the amount claimed or reduced in amount. Presented to the Legislature, 9th June, 1922. *Mr. Hay. Not printed.*
No. **101**	Return to an Order of the House of the 24th February, 1922, that there be laid before the House a Return of all papers, documents, memoranda, recommendations, letters, telegrams and communications of every kind between any Municipal corporations, associations, bodies or persons and the Prime Minister or any Minister of the Government regarding the appointment or suggestion to appoint Peter Heenan, M.P.P. for Kenora, a Member of the Hydro-Electric Power Commission of Ontario. Presented to the Legislature, 9th June, 1922. *Mr. Thompson. Not Printed.*

REPORT

OF THE

Minister of Lands and Forests

For Year 1921

BOUND IN VOL. LIII

PART II, 1921

PROVINCE OF ONTARIO
DEPARTMENT OF MINES

HON. H. MILLS, MINISTER OF MINES — THOS. W. GIBSON, DEPUTY MINISTER

THIRTY-FIRST ANNUAL REPORT

OF THE

ONTARIO DEPARTMENT OF MINES

BEING

VOL. XXXI, PART I, 1922

CONTENTS

	Page
Statistical Review, 1921, by W. R. Rogers	1-52
Gravel Deposits of the St. Clair River by Jas. Bartlett	53-61

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY OF ONTARIO

TORONTO:
Printed by CLARKSON W. JAMES, Printer to the King's Most Excellent Majesty
1924

Printed by
THE RYERSON PRESS

CONTENTS, PART I

PAGE

- Letter of Transmission vi
- Introductory Letter vii

STATISTICAL REVIEW OF ONTARIO'S MINERAL INDUSTRY IN 1921

- Table I—Summary of Mineral Statistics of Ontario for 1921 ... 2
- Table II—Value of Mineral Production, 1917 to 1921 3
- Table III—Value of Total Production of Metals in Ontario ... 4

GOLD—

- Producing Gold Mines, 1921 5
- Table IV—Ontario's Gold Production, 1921 5
- Table V—Total Gold Production of Ontario 6
- Table VI—Dividends and Bonuses Paid by Gold Mining Companies to December 31, 1921 7

SILVER-COBALT—

- Silver Producers in 1921 8
- Table VII—Shipments from Silver Mines, 1904 to 1921 9
- Table VIII—Total Shipments from Silver Mines, 1904 to 1921 10
- Table IX—Silver Shipments by Camps 11
- Operations of Silver-Cobalt Refineries in Ontario, 1921 12
- Table X—Dividends and Bonuses Paid by Silver Mining Companies to December 31, 1921 ... 13-14

NICKEL, COPPER AND THE PLATINUM METALS—

- Table XI—Nickel-Copper Mining and Smelting, 1917-1921 16
- Table XII—Nickel-Copper Refining, 1921 16
- Platinum Metals 16

IRON ORE—

- Shippers of Iron Ore, 1921 17

PIG IRON, STEEL AND FERRO-ALLOYS 18
- Blast Furnaces in Ontario 18
- Iron Blast Furnaces in Operation, 1921 18
- Table XIII—Iron and Steel Statistics, 1917-1921 19

LEAD 19

NON-METALLIC MINERALS.

- Actinolite 20
- Barite 20
- Calcite and Dolomite 20
- Corundum 20
- Feldspar 20
  - Feldspar Shippers, 1921 21
- Fluorspar 21
  - Fluorspar Shippers, 1921 22
- Graphite 22
  - Graphite Operators, 1921 22
- Gypsum 22
- Iron Pyrites 23
  - Iron Pyrites Shippers, 1921 23
- Mica 23
  - Mica Shippers, 1921 24
- Mineral Waters 24
- Natural Gas 24
- Peat 25
- Petroleum 25
  - Petroleum Refineries, 1921 26
  - Crude Petroleum and Refinery Statistics, 1917-1921 26
- Quartz and Silica Brick 27
  - Quartz Shippers, 1921 27
- Salt 27
  - Salt Statistics, 1917-1921 27
  - Salt Companies, 1921 28
- Talc and Soapstone 28
  - Talc Statistics, 1917-1921 28
  - Talc Operators, 1921 29

STRUCTURAL MATERIALS.

- Clay Products 29
  - Sewer Pipe and Pottery Works, 1921 29
  - Value of Clay Products sold or used, 1913-21 30
  - Brick and Tile Plants, 1921 30
- Portland Cement 33
  - Portland Cement Plants Operating in 1921 33
  - Portland Cement Statistics, 1913-1921 33
  - Concrete Products 33
  - Concrete Products Statistics, 1917-1921 34
  - Producers of Concrete Products, 1921 34
- Lime 36
  - Lime Statistics, 1917-1921 37
  - Lime Producers, 1921 37
- Sand-Lime Brick 38
  - Sand-Lime Brick Producers, 1921 38
- Sand and Gravel 38
  - Sand and Gravel Operators, 1921 .. 38
  - Sand and Gravel Licensees, 1921 .. 41
- Stone 42
  - Stone Quarry Operators, 1921 42
  - Value of Stone Production, 1917-1921 42

- Mining Divisions 43
  - Moneys Remitted by Mining Recorders for the Fiscal Year ending October 31, 1921 44
  - Summary of Business in the several Mining Divisions for the Calendar Year, 1921 45

Page
Mining Revenue 46
  Mining Lands Sold and Leased in Year ending October 31st, 1921 46
  Details of Profit Tax 47
Mining Companies Incorporated and Licensed 47
  Mining Companies Incorporated in 1921 48
  Mining Companies Licensed in 1921 49
  Mining Company Charters Surrendered in 1921 49
Provincial Assay Office 49
  Tariff of Fees for Analyses and Assays 50
Departmental Correspondence 52

GRAVEL DEPOSITS OF THE ST. CLAIR RIVER

Page
Sand and Gravel Definitions and Specifications 53
Origin of the Deposits 55
Rate of Growth of the Deposits..... 56
The Gravel Boats 57
Results of Screen Tests............ 57
Pebbles 57
Selling Prices of the Gravel........ 58
Details of the Deposits 58
Gravel Tests 60
Future Demand for the Gravel...... 61
Conclusions 61
Acknowledgments 61

ILLUSTRATIONS AND MAP

Self-loading Boats dredging gravel below the "Tunnel," St. Clair River 56
Gravel Boat leaving Dredge after being loaded, St. Clair River 57
Map of the St. Clair River, scale three miles to the inch, ...*insert facing* 58

LETTER OF TRANSMISSION

To His Honour, Henry Cockshutt,

Lieutenant-Governor of the Province of Ontario.

Sir,—I have the honour to transmit to you herewith, for presentation to the Legislative Assembly of the Province of Ontario, the Thirty-first Annual Report of the Department over which I have the honour to preside.

I have the honour to be, Sir,

Your obedient servant,

Henry Mills,
Minister of Mines.

Department of Mines,
Toronto, 1923.

Introductory Letter

To the Honourable H. Mills,

Minister of Mines.

Sir:—

I beg to submit to you herewith the Thirty-first Annual Report of the Department of Mines. The Report comprises ten parts, published separately, as follows:—

Part 1.—Statistical Review of the Mining Industry of Ontario, with a variety of Tables illustrating the course of the industry during the year 1921, by W. R. Rogers; also Gravel Deposits in the St. Clair River, by James Bartlett, Inspector of Mines. The St. Clair River is an important source of these materials for road building and other construction purposes.

Part 2.—Geology of the Mine Workings of Cobalt and South Lorrain Silver Areas, by C. W. Knight, Associate Provincial Geologist, together with a description of mining and metallurgical practice in treatment of silver ores at Cobalt by Fraser D. Reid, James J. Denny and R. H. Hutchison. Mr. Knight made an extended and thorough investigation into the structural conditions of the mines of Cobalt, as revealed in the underground workings, and particularly into the relationships existing between the ore bodies and the surrounding rocks. In presenting his conclusions, Mr. Knight also brings together a mass of interesting material regarding one of the richest and most remarkable silver areas ever discovered. Particulars are also given of the valuable deposits being uncovered in South Lorrain at the time the Report was written.

Part 3.—The Blanche River Area, with Map No. 31b, by A. G. Burrows and P. E. Hopkins.

Part 4.—Fourth Report of Joint Peat Committee, by B. F. Haanel, Secretary.

Part 5.—Natural Gas and Petroleum in 1921, by R. B. Harkness, Natural Gas Commissioner.

Part 6.—Geology and Minerals of the County of Leeds, with Map No. 31c, by Prof. M. B. Baker, of Queen's University, Kingston.

Part 7.—Geology of the Watabeag Area, with Map No. 31d, by Douglas G. H. Wright.

Part 8.—Iron Formation of Lake St. Joseph, with Maps Nos. 31e and 31f, by Prof. E. L. Bruce, of Queen's University, Kingston.

Part 9.—The Stratigraphy and Paleontology of Toronto and Vicinity (Part III.—Gastropoda, Cephalopoda and Vermes, with six plates), by Prof. W. A. Parks and Madeleine Fritz, of the University of Toronto.

Part 10.—Mining Accidents in 1921, and Mines of Ontario, by T. F. Sutherland, Chief Inspector of Mines, and Inspectors G. E. Cole, James Bartlett, J. G. McMillan and A. R. Webster; also Instruction Classes for Prospectors, by Dr. W. L. Goodwin, and Notes on Clays of the Missinaibi River, by Joseph Keele.

I venture to think that the series of Reports contained in Volume XXXI, makes a substantial addition to the existing stock of information regarding the mining industry and mineral resources of Ontario.

I have the honour to be, Sir,

Your Obedient servant,

Thos. W. Gibson,

Deputy Minister of Mines.

Department of Mines,
Toronto, 1923.

STATISTICAL REVIEW
OF
ONTARIO'S MINERAL INDUSTRY IN 1921.

By W. R. Rogers.

The mining industry as a whole, in common with most other lines of business, experienced a year of depression. Post-war conditions have been reflected in the fluctuating values obtained for mineral products. The general deflation in commodity prices experienced in 1919 was followed during the greater part of 1920 by a return to higher levels. In 1921 most branches of the industry again passed through a period of deflation, and prices in some cases returned to pre-war levels. This condition is exemplified in the case of nickel, copper and pig iron. Some non-metallics which may be classed as war minerals experienced a decrease in output and lowering of prices. In the building industries there are evidences of a revival, brought about in part by a decline in cost of materials.

A scheme of co-operation has been effected with the Dominion Bureau of Statistics, Ottawa, whereby uniform blank forms are used in collecting statistics. This saves the operators expense and inconvenience, the same forms serving both statistical bureaus.

During the war period attention was directed largely to the production of war metals such as nickel, copper, iron and molybdenum. Subsequently the demand slackened, more particularly as regards nickel and copper. Owing to an over-stocked market and consequent low prices, the nickel-copper producing companies curtailed operations or shut down entirely, pending the absorption of surplus stock. Meantime, as nickel requirements for armament purposes had declined, new uses for nickel were being investigated with a view to extending the market for the industrial consumption of this metal. Ontario, which produces 90 per cent. of the world's nickel supply, is vitally interested in the success of the nickel industry.

The outstanding feature in Ontario's mineral industry is the growing importance of the Province as a producer of gold. The situation for gold-mining companies improved greatly during the year. Labour became more plentiful, more efficient and cheaper; costs of supplies declined and gold commanded a premium. The exchange premium, however, which was at its maximum at the beginning of the year declined gradually, and is still declining. This, however, is not a factor on which the success or failure of the gold-mining industry in this Province depends. Every indication points to greatly increased gold production in the future. A shortage of hydro-electric power curtailed the output in the spring of 1921.

Details regarding output and conditions in the several phases of the mining industry are noted under separate headings. The value of metalliferous production exceeded that of any pre-war year, while the non-metallic valuation was the greatest in Ontario's history. Table I, which follows, gives a summary of Ontario's mineral production in 1921, together with the number of employees and wages paid to wokmen by operators. Table II on page 3 shows the valuation itemized for the last quinquennial period.

TABLE 1.—SUMMARY OF MINERAL STATISTICS OF ONTARIO FOR 1921

Product	Quantity	Value	Employees	Wages
METALLIC:		$		$
Gold.......................ounces	710,812	14,692,357	2,761	4,368,070
Silver.......................“	8,435,593	5,673,908	1,074	1.440,144
Copper in matte (*a*)..........short tons	3,686	737,142	1,895	1,557.696
Nickel in matte (*a*)..........“	4,850	1,939,851		
Iron ore (*b*)..........“	100	459	44	68,859
Iron, pig (*c*)..........“	66,316	1,588,751	391	620,938
Lead, pig..........lbs.	3,576,222	191,113	15	17,830
Copper..........“	3,131,762	364,588	(*d*) 454	367,216
Nickel, metallic..........“	5,430,147	1,825,359		
Nickel oxide..........“	1,402,019	285,391		
Platinum metals..........ounces	13,418	862,034		
Cobalt, metallic and in residues......lbs.	38,544	147,952	(*e*) 225	325.466
Cobalt oxide..........“	165,554	354,418		
Other Cobalt and Nickel compounds..“	111,178	114,258		
Total metallic..........	....	28,777,581	6,859	8,766.219
NON-METALLIC:				
Actinolite..........tons..	78	975	6	215
Arsenic, white..........“	1,491	233,763	(*e*)	(*e*)
Clay products—($5,183,125).				
Brick, common..........M..	114,583	2,025,643	1,703	1.369.731
Brick, fancy and pressed..........“..	58,904	1,241,375		
Tile, drain..........“..	....	397,104		
Tile, building and floor tile.......tons..	....	421,127		
Pottery..........	....	69,984	24	28,502
Sewer pipe..........	....	939,463	230	272,837
Cement, Portland..........bbls.	2,723,071	6,424,356	883	1,228,460
Corundum..........tons	403	55,965	34	16.885
Feldspar..........“	20,115	150,457	82	95,469
Fluorspar..........“	116	1,744	5	132
Graphite, crude and refined..........“	899	63,439	32	13,198
Gypsum, crushed, ground and calcined “	84,790	433,053	109	122,549
Iron pyrites..........“	27,785	101,306	96	97,653
Lime—				
Quicklime..........bush.	2,763,062	962,439	366	341.826
Hydrated..........tons	26,862	381,749		
Mica..........“	218	28,891	28	23,539
Mineral water..........Imp. gals.	308,647	14,438	1	923
Natural gas..........M. cu. ft.	8,532,234	2,975,502	554	504,497
Peat..........tons	1,666	6,664	18	11,662
Petroleum, crude..........bbls.	172,859	559,198	147	149,395
Quartz and silica brick..........tons	72,068	220,806	109	49,017
Salt..........“	161,987	1,649,626	264	311,205
Sand and gravel..........“	6,273,173	1,496,729	307	228.628
Sand-lime brick..........M	36,482	534,531	131	141,460
Stone, building, trap, granite, etc....tons	2,716,080	4,167,582	809	702,507
Talc, crude and ground..........“	9,967	140,390	30	41,978
Total non-metallic..........	....	25,786,728	5,968	5,752,268
Add metallic..........	....	28,777,581	6,859	8,766,219
Grand total..........	....	54,564,209	12,827	14,518,487

(*a*) Copper and nickel in the matte valued at 10 and 20 cents per pound respectively.

(*b*) Exports and shipments to points other than Ontario blast furnaces. Total shipments of iron ore, 58,499 tons, valued at $227,134.

(*c*) Production from Ontario ore only. Total output of blast furnaces, 494,901 tons of pig iron, worth $11,856,352

(*d*) Employees and wages for nickel-copper refineries.

(*e*) Employees and wages for silver-cobalt smelters and refineries.

The following comparative statement shows the course of the mining industry during the five-year period, 1917 to 1921 inclusive, as indicated by the value of the total production:

TABLE II.—VALUE OF MINERAL PRODUCTION, 1917 TO 1921.

Product.	1917	1918	1919	1920	1921
METALLIC:	$	$	$	$	$
Gold	8,698,735	8,502,480	10,451,709	11,686,043	14,692.357
Silver	16,183,208	17,415,882	12,904,312	10,873,496	5,763.908
Platinum metals	....	....	200,000	1,996,535	862,034
Cobalt (*a*)	1,122,779	1,615,130	868,107	1,603,736	502,370
Nickel (*b*)	21,041,956	27,840,422	11,925,220	15,689,131	4,050,601
Other Nickel and Cobalt compounds.	42,026	73,347	188,083	16,959	114,258
Copper, metallic and in matte	7,961,662	8,532,790	3,709,687	3,970,744	1,101,730
Iron ore (*c*)	483,690	624,364	48,341	60,981	459
Pig iron (*d*)	1,016,699	1,364,736	1,200,793	2,204,205	1,588,751
Lead (pig)	172,601	149,841	94,507	179,714	191,113
Molybdenite	108,501	59,067	....	....	....
Metallic production	56,831,857	66,178,059	41,590,759	48,281,553	28,777,581
NON-METALLIC:					
Actinolite	1,320	2,508	1,176	1,160	975
Arsenic	608,483	566,332	485,360	432,434	233,763
Asbestos	2,150	....	....	....	....
Barite	....	900	....	....	....
Brick, common	800,983	756,962	2,334,526	2,617,031	....
Brick, sand-lime	....	....	....	....	534,531
Brick, fancy, and pressed	474,614	396,698	539,908	809,126	....
Cement, Portland	2,934,271	1,910,839	3,659,720	4,377,814	6,424,356
Corundum	31,213	26,120	....	27,000	55,965
Feldspar	81,802	111,173	88,663	268,295	150,457
Fluorspar	66,474	153,190	60,389	67,381	1,744
Graphite	296,587	208,848	99,841	132.882	63,439
Gypsum	130,138	151,564	278,111	404.162	433.053
Iron pyrites	1,111,264	1,144,737	366,422	618.283	101.306
Lime	657,364	872,177	1,268,290	1,799,763	1,344,188
Mica	92,453	49,575	56,199	54,169	28.891
Mineral water	(*e*)	133,808	19,290	15,059	14,438
Natural gas	3,220,123	2,498,769	2,583,324	3,163,500	2,975,502
Peat fuel	....	....	1,750	15,600	6,664
Petroleum (crude)	475,000	781,097	632,789	724,145	559,198
Phosphate of lime (apatite)	....	....	31	....	....
Pottery	94,501	88,275	119,551	127,049	....
Quartz (silica)	358,674	452,711	179,070	366,441	220,806
Salt	1,047,707	1,287,039	1,395,368	1,544,867	1,649,626
Sand and gravel	431,597	553,638	501,666	1,390,704	1,496,729
Sewer pipe	378,923	362,536	609,100	860,811	....
Stone, building, crushed, etc	939,052	869,239	1,230,922	3,944,972	4,167,582
Talc, crude and ground	179,554	246,691	240,399	306,319	140,390
Tile, drain	546,040	309,899	354,700	359,373	....
Tile, building and roofing	301,688	195,588	186,592	369,530	....
Non-metallic production	15,261,975	14,130,913	17,293,157	24,797,969	25,786,728
Add metallic production	56,831,857	66,178,059	41,590,759	48,281,553	28,777,581
Total production	72,093,832	80,308,972	58,883,916	73,079,522	54,564,209

(*a*) Cobalt oxide, metallic cobalt, and cobalt content of residues marketed.
(*b*) Nickel in matte, oxide and metallic nickel.
(*c*) Exports and shipments to points other than Ontario blast furnaces.
(*d*) Product from Ontario ore only.
(*e*) Production figures not collected.

In Table III is given the aggregate value of the metals and metallic products since the several substances began to be produced in Ontario down to the end of 1921. It should be pointed out that since 1914 the statistics of annual production credit pig iron only with the value of the pig iron product made from Ontario ore. This is but a small part of the total output, since the great bulk of the iron ore charged into the blast furnaces of the Provinces is "lake" ore from the mines of Michigan, Minnesota and Wisconsin. Conversely, part of the iron ore raised in Ontario is exported to the United States in the form of briquettes produced from low-grade magnetite ores. In the production tables credit is taken only for the ore exported or shipped to points other than Ontario blast furnaces, since to include the value of the domestic ore converted into pig iron in Ontario furnaces would involve a duplication of this item.

TABLE III.—VALUE OF TOTAL PRODUCTION OF METALS IN ONTARIO.

Metal or Product	Production to 31st December, 1920	Production, 1921	Production to 31st December, 1921
	$	$	$
Gold	73,192,873	14,692,873	87,885.230
Silver	208,805.398	5,673,908	214,479,306
Platinum metals	3,496.535	862,034	4,358,569
Cobalt, including Cobalt oxide	8,390,742	502,370	8.893.112
Nickel, including Nickel oxide	165,624,893	4,050,601	169,675,494
Other Cobalt and Nickel compounds	435,819	114,258	550,077
Copper	57,627,511	1,093,850	58.721.361
Iron ore	9,411,234	459	9,411,693
Pig iron	82,330,915	1,588,751	83.919.666
Lead	784,816	191,113	975.929
Zinc ore	92,410	....	92,410
Molybdenite	209,735	....	209,735
Total	610,402,881	28,777,581	639,180,462

Gold

Ontario's gold production of $14,692,357 in 1921 was nearly three million dollars or over 25 per cent. in excess of the 1920 output. During the last quarter of the year bullion worth $4,832,305 was produced, or at the rate of $19,329,220 per annum. With considerably augmented milling capacity at both Porcupine and Kirkland Lake the 1922 production is expected to show a marked increase over 1921. From 1904 to 1919 Ontario's output of silver exceeded gold in valuation, but in 1920 this position was reversed. During the first quarter of 1921 the gold mines were unable to operate to capacity owing to hydro-electric power shortage; otherwise the year's showing would be still more satisfactory. Operating conditions are steadily improving both as regards labour and supplies.

The Wright-Hargreaves at Kirkland Lake started its 175-ton mill in May and an initial dividend of 5 per cent. was paid on January 1st, 1922. In the same area the Ontario-Kirkland, another new producer, tuned up its 110-ton mill in December, and cyaniding was under way by the middle of January, 1922.

Expansion of milling capacity at Porcupine has been deterred by reason of the uncertainty of an adequate hydro-electric power supply. The Northern Canada Power Company has recently come to an agreement with the McIntyre mine to take over the latter's power rights at Sturgeon falls on the Mattagami river, 28 miles to the north of Porcupine, where a development of 7,000 horsepower is possible. Work will proceed at once and power should be available by the end of 1922, thereby increasing Porcupine's power supply by about 50 per cent. An increase of milling capacity from 550 to 800 tons is proceeding at the McIntyre. The Hollinger, which was treating about 4,000 tons of ore daily at the end of the year, also plans greater capacity, but additional power will be necessary, so application has been made to the Ontario Government for a waterpower lease at a point on the Abitibi river, 12 miles north of Cochrane.

The following operators produced gold in 1921:

PRODUCING GOLD MINES, 1921

Name of Company.	Name of Mine.	Locality.	P.O. Address of Manager, etc.
Argonaut Gold, Limited	Argonaut	Gauthier tp.	Dane.
Dome Mines Company, Limited	Dome and Dome Extension	Porcupine	South Porcupine.
Hollinger Consolidated Gold Mines, Limited	Hollinger	Porcupine	Timmins.
Kirkland Lake Gold Mining Company, Limited	Kirkland Lake	Kirkland Lake	Kirkland Lake.
Lake Shore Mines, Limited	Lake Shore	Kirkland Lake	Kirkland Lake.
McIntyre Porcupine Mines, Limited	McIntyre	Porcupine	Schumacher.
Northcrown Porcupine Mines, Ltd.	Northcrown	Porcupine	Timmins.
Pilon, A., and Richards, M.	T.B., 1471-2	Sturgeon Lake	Northpines.
St. Anthony Mine Syndicate	St. Anthony	Sturgeon Lake	Toronto.
Teck-Hughes Gold Mines, Limited	Teck-Hughes	Kirkland Lake	Kirkland Lake.
Wright-Hargreaves Mines, Limited	Wright-Hargreaves	Kirkland Lake	Kirkland Lake.

Details of production are given in the table which follows:

ONTARIO'S GOLD PRODUCTION, 1921.

Source	Ore Milled, tons	Bullion shipped				Total Value Bullion
		Gold		Silver		
		Fine ounces	Value	Fine ounces	Value	
PORCUPINE			$		$	$
Dome	335,680	110,316	2,280,237	15,628	10,027	2,290,264
Hollinger Consolidated	1,072,493	435,404	8,999,796	80,911	51,480	9,051,276
McIntyre	172,287	87,837	1,815,597	20,321	12,164	1,827,761
Northcrown	....	382	7,896	69	47	7,943
Total	1,580,460	633,939	13,103,526	116,929	73,718	13,177,244
KIRKLAND LAKE						
Kirkland Lake	43,966	11,678	241,379	1,665	1,037	242,417
Lake Shore	21,817	23,896	493,940	2,025	1,336	495,276
Teck-Hughes	34,693	15,582	322,028	1,305	891	322,919
Wright-Hargreaves	36,053	22,617	467,504	2,066	1,248	468,751
Total	136,529	73,773	1,524,851	7,061	4,512	1,529,363
MISCELLANEOUS						
Argonaut	Clean-up	25	510	4	3	513
Pilon and Richards	30	54	1,113	12	9	1,122
St. Anthony—						
1920*	....	420	8,688	82	83	8,771
1921	320	243	5,032	59	36	5,068
Nickel-Copper refining	....	2358	48,637	....	....	48,637
Total	350	3100	63,980	157	131	64,111
GRAND TOTAL	1,717,339	710,812	14,692,357	124,147	78,361	14,770,718

---

*Not previously reported.

Exchange on New York funds averaged 11.61 per cent. for the year as compared with 12.27 in 1920. Ontario gold producers, in addition to the values given in the table on page 5, received $1,359,636 by way of exchange premium.

In the following table the total gold output of the Province is given, also that from Porcupine and Kirkland Lake beginning in 1910 and 1913 respectively:—

TABLE V.—TOTAL GOLD PRODUCTION OF ONTARIO

Year	Total Production	Porcupine		Kirkland Lake	
	Value $	Value $	Per Cent.	Value $	Per Cent.
1866-1891	190,258*	.....	.....	.....	.....
1892-1909	2,509,492	.....	.....	.....	.....
1910	68,498	35,539	51.8	.....	.....
1911	42,637	15,437	36.2	.....	.....
1912	2,114,086	1,730,628	81.8	.....	.....
1913	4,558,518	4,294,113	94.1	65,260	1.2
1914	5,529,767	5,190,794	93.8	114,154	2.0
1915	8,501,391	7,536,275	88.6	551,069	6.5
1916	10,339,259	9,397,536	90.8	702,761	6.8
1917	8,698,735	8,229,744	94.5	404,346	4.6
1918	8,502,480	7,767,907	91.4	632,007	7.4
1919	10,451,709	9,941,804	95.1	486,809	4.7
1920	11,686,043	10,597,573	90.7	1,033,478	8.8
1921	14,692,357	13,103,526	89.3	1,524,851	10.4
Total	87,885,230	77,840,876	88.6	5,514,735	6.3

*Estimated.

Dividends.—The important period of gold mining in Ontario began with the opening of the Porcupine mines in 1910. Since that time the gold mines have paid out in returns to shareholders a total of $23,140,734.85, details of which are given in Table VI.

TABLE VI.—DIVIDENDS AND BONUSES PAID BY GOLD MINING COMPANIES TO DECEMBER 31, 1921.

Name of Company	Date of Incorporation	Authorized Capital	Capital Stock Issued	Par value per share	Amount of Dividends and Bonuses paid to end of 1920	Amount of Dividends and Bonuses paid during 1921	Rate per cent.	Total of Dividends and Bonuses paid to Dec. 31st, 1921	Date when last Dividend or Bonus paid
		$	$	$ c.	$ c.	$ c.		$ c.	
*Dome Mines Company, Ltd.	Mar. 23, 1910	5,000,000	4,766,670	10 00	1,916,886 00	474,525 75	10	2,391,411 75	Oct. 20, 1921
†Hollinger Cons. Gold Mines, Ltd.	May 25, 1916	25,000,000	24,600,000	5 00	13,360,000 00	3,198,000 00	13	16,558,000 00	Dec. 31, 1921
Lake Shore Gold Mines, Ltd.	Feb. 25, 1914	2,000,000	2,000,000	1 00	280,000 00	120,000 00	6	400,000 00	Nov. 10, 1921
McIntyre-Porcupine Mines, Ltd.	Mar. 16, 1911	4,000,000	3,640,283	1 00	1,994,655 65	546,042 45	15	2,540,698 10	Sept. 1, 1921
Porcupine Crown Mines, Ltd.	May 26, 1913	2,000,000	2,000,000	1 00	840,000 00	....	......	840,000 00	July 15, 1917
Rea Consolidated Gold Mines	April 5, 1911	1,000,000	200,000	5 00	12,000 00	....	......	12,000 00	....
Tough-Oakes Gold Mines, Ltd.	July 15, 1913	3,000,000	2,657,500	5 00	398,625 00	....	......	398,625 00	Dec. 27, 1916
Total	....	....	....	......	18,802,166 65	4,338,568 20	......	23,140,734 85	

*Dividends in 1921 include $4,079 paid to former Dome Extension shareholders.

†Hollinger Consolidated Gold Mines, Limited, is a consolidation of the Acme Gold Mines, Limited, Millerton Gold Mines, Limited, and Hollinger Gold Mines, Limited. Dividends include $160,000 paid by Acme prior to the amalgamation.

Silver—Cobalt

Although the price of silver dropped from an average of 100.90 cents in 1920 to 62.65 in 1921, production was well maintained. Several mines which were forced to close down in the fall of 1920 owing to power shortage have not reopened. In South Lorrain the Keeley mine has struck rich ore and is producing concentrates in its new mill. The adjoining Frontier mine, which has been optioned by the Mining Corporation of Canada, was also a producer. During the year an underground survey of silver mines at Cobalt and South Lorrain was completed by C. W. Knight, Associate Provincial Geologist. His report will appear as Volume XXXI, Part 2.

Mines shipping over a quarter million ounces of silver in 1921 are given in order:

Mine.	Ounces.
Nipissing	3,012,680
O'Brien	1,366,686
Coniagas	1,301,860
Mining Corporation of Canada	911,899
La Rose	658,423
Keeley	281,659

In addition to the silver content of ores, concentrates, residues, etc., producing mines are paid for the cobalt content provided the percentage is sufficiently high. Mine shippers in 1921 were paid $48,512 for 185,442 pounds of cobalt.

From weekly statements, issued by the General Freight and Passenger Agent of the Temiskaming and Northern Ontario Railway, showing railway shipments of ore, concentrates, etc., from the Cobalt area the following information has been compiled: Total shipments, 2,616 tons of which 1,479 were consigned to southern Ontario and 1,137 tons to United States smelters and refineries.

Classified according to source, the output of silver in 1921 was derived as follows:

	Ounces.
Cobalt	7,673,535
South Lorrain	328,886
Gowganda	258,292
Casey township	1,101
James township (Elk Lake)	117
Recovered from gold ores	124,147
Recovered from nickel-copper refining	49,515
Total	8,435,593

The producers of silver are given in the following list:—

SILVER PRODUCERS IN 1921

Operator.	Mine or Source.	Location.
Aladdin Cobalt Company, Limited	Chambers-Ferland	Cobalt.
Bailey Silver Mines, Limited	Bailey and Silver Cliff	Cobalt.
Beaver Consolidated Mines, Limited	Beaver	Cobalt.
Bennett, N. W.	Casey-Cobalt mill clean-up	Casey tp.
Benson, G. H.	Silver Leaf dump	Cobalt.

SILVER PRODUCERS IN 1921—*Continued.*

Operator	Mine or Source	Location
Camburn Silver Mines	Lumsden	Cobalt.
Chitty & Johns	Ophir dump	Cobalt.
Chitty & Johns	People's silver mine	Cobalt.
Colonial Mining Company, Limited	Colonial	Cobalt.
Coniagas Mines, Limited	Coniagas and Trethewey	Cobalt.
Crown Reserve Mining Company, Ltd	Crown Reserve	Cobalt.
Dominion Reduction Company	Dominion	Cobalt.
Frontier Mine	Frontier	South Lorrain.
Hudson Bay Mines, Limited	Hudson Bay	Cobalt.
Keeley Silver Mines, Limited	Keeley	South Lorrain.
Kerr Lake Mining Company, Limited	Kerr Lake	Cobalt.
La Rose Mines, Limited	La Rose	Cobalt.
McKinley-Darragh-Savage Mines of Cobalt, Limited	McKinley-Darragh-Savage.	Cobalt.
McKinney, S. T	Smelter clean-up	Orillia.
Mining Corporation of Canada, Limited, The	Cobalt Lake, Townsite-City, Buffalo	Cobalt.
Mosure, F. B	Various mine samples	Cobalt.
Nipissing Mining Company, Limited	Nipissing	Cobalt.
O'Brien, M. J., Limited	O'Brien	Cobalt.
" "	Miller Lake O'Brien	Gowganda.
Penn Canadian Mines, Limited	Mill clean-up	Cobalt.
Post, W. J	Silver Queen (lease)	Cobalt.
Regent Mines, Limited	Regent	James tp.
Trethewey Silver-Cobalt Mine, Limited	Castle	Gowganda.

In Table VII are shown the shipments of ore, concentrates and bullion from the mines of Cobalt, South Lorrain, Gowganda and outlying silver areas since mining began in 1904. By "shipment" is meant consignment to outside points whether in Canada or abroad, but not movements within the camp, for example, ore shipped from a mine to a concentrating or reduction plant in Cobalt itself. It will be noted that the quantity of ore shipped away from the camp has been reduced to relatively small proportions during recent years. The table follows:

TABLE VII.—SHIPMENTS FROM SILVER MINES, 1904 TO 1921.

Year	No. of Producing Mines	Ore.			Concentrates and Residues			Bullion	Total	
		Tons	Silver, Ounces	Ave. per ton Oz.	Tons	Silver, Ounces	Ave. per ton Oz.	Ounces	Ounces	Value $
1904	4	158	206,875	1,309					206,875	111,887
1905	16	2,144	2,451,356	1,143					2,451,356	1,360,503
1906	17	5,335	5,401,766	1,013					5,401,766	3,667,551
1907	28	14,788	10,023,311	677					10,023,311	6,155,391
1908	30	24,487	18,022,480	736	1,137	1,415,395	1,244		19,437,875	9,133,378
1909	31	27,729	22,436,355	809	2,948	3,461,470	1,714		25,897,825	12,461,576
1910	41	27,437	22,581,714	821	6,845	7,082,834	1,030	980,633	30,645,181	15,478,047
1911	34	17,278	20,318,626	1,176	9,375	8,056,189	858	3,132,976	31,507,791	15,953,847
1912	30	10,719	15,395,504	1,436	11,214	9,768,228	871	5,080,127	30,243,859	17,408,935
1913	35	9,861	13,668,079	1,386	10,016	8,489,321	770	7,524,575	29,681,975	16,553,981
1914	32	4,302	6,504,753	1,511	12,152	8,915,958	733	9,742,130	25,162,841	12,765,461
1915	24	2,865	6,758,286	2,359	11,996	10,001,548	834	7,986,700	24,746,534	12,135,816
1916	28	2,177	4,672,500	2,146	8,561	7,598,011	887	7,644,579	19,915,090	12,643,175
1917	28	2,288	3,271,353	1,429	13,720	6,445,243	469	8,053,318	19,401,893	16,121,013
1918	38	1,456	1,401,050	962	17,958	5,793,756	323	10,466,888	17,661,694	17,341,790
1919	33	850	806,341	949	15,208	4,024,764	265	6,383,764	11,214,317	12,738,994
1920	35	578	668,081	1,152	9,757	3,777,812	387	6,402,423	10,845,436	10,654,471
1921	28	948	986,597	1,041	3,101	2,962,771	955	4,312,603	8,261,931	5,564,594
Total		155,400	155,573,027	1,001	134,988	87,802,748	650	77,710,716	322,707,550	198,250,410

TABLE VIII.—TOTAL SHIPMENTS FROM SILVER MINES, SMELTERS AND REFINERIES, 1901 TO 1921.

Year	Copper (*a*)		Lead (*a*)		Nickel (*b*)		Cobalt (*c*)		Arsenic		Silver		Total Value
	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Ounces	Value	
		$		$		$		$		$		$	$
1904					14	3,467	16	19,960	72	903	206,875	111,887	136,217
1905					75	10,000	118	100,000	549	2,693	2,451,356	1,360,503	1,473,196
1906					160		321	80,704	1,440	15,858	5,401,766	3,667,551	3,764,113
1907					370	1,174	739	104,426	2,958	40,104	10,023,311	6,155,391	6,301,095
1908					612		1,224	111,118	3,672	40,373	19,437,875	9,133,378	9,284,869
1909					766		1,533	94,965	4,294	61,039	25,897,825	12,461,576	12,617,580
1910					504		1,098	54,699	4,897	70,709	30,645,181	15,478,047	15,603,455
1911					392		852	170,890	3,806	74,609	31,507,791	15,953,847	16,199,346
1912					429	14,220	934	314,381	4,166	80,546	30,243,859	17,408,935	17,818,082
1913					377	13,326	821	420,386	3,663	64,146	29,681,975	16,553,981	17,051,839
1914 (*d*)					90	28,978	351	590,406	2,030	116,624	25,162,841	12,765,461	13,501,469
1915					35	28,353	206	383,261	2,490	148,379	24,746,534	12,135,816	12,695,809
1916					79	59,380	400	805,014	2,160	200,103	19,915,090	12,643,175	13,707,672
1917	53	28,840			155	125,071	337	1,138,190	2,592	608,483	19,401,893	16,121,013	18,021,597
1918	72	35,712	3	453	186	156,893	380	1,640,310	2,545	566,332	17,661,694	17,341,790	19,741,490
1919	110	40,976	12	1,296	276	188,418	298	1,019,479	2,834	485,360	11,214,317	12,738,994	14,474,523
1920	50	17,494	5	792	127	93,233	283	1,605,365	1,883	431,527	10,846,321	10,654,471	12,802,882
1921	103	34,504	3	270	10	7,665	126	616,235	1,491	233,763	8,261,931	5,564,594	6,457,031
Total	388	157,526	23	2,811	4,657	730,178	10,037	9,269,789	47,542	3,241,551	322,708,435	198,250,410	211,652,265

(*a*) Copper and lead are recovered from certain silver ores and concentrates shipped to United States refineries. These metals are valued at the average prices for the year, namely: copper, 12.5 cents and lead 8.5 cents per pound in 1921.

(*b*) Nickel metal and metallic contents of all Nickel compounds.

(*c*) Cobalt metal and metallic contents of all Cobalt compounds.

(*d*) Prior to 1914 an estimate based on assays was made of the nickel, cobalt and arsenic contained in the ores; subsequently actual recoveries have been reported.

Since the discovery of silver at Cobalt in 1903 shipments from the camp and outlying silver areas have been as follows:

TABLE IX.—SILVER SHIPMENTS BY CAMPS

Year	Average price, cents per ounce (New York)	Silver Shipments in Troy Ounces, 1904-1921					
		Total Ounces	Cobalt	Casey Township	South Lorrain	Gowganda	Montreal River and Maple Mountain
1904	57.221	206,875	206,875	....	....	....	....
1905	60.352	2,451,356	2,451,356	....	....	....	....
1906	66.791	5,401,766	5,401,766	....	....	....	....
1907	65.237	10,023,311	10,023,311	....	....	....	....
1908	52.864	19,437,875	19,424,251	500	13,124	....	....
1909	51.502	25,897,825	25,658,683	26,185	194,955	....	18,002
1910	53.486	30,645,181	29,849,981	92,544	221,133	471,688	9,835
1911	53.340	31,507,791	29,989,893	114,789	933,912	468,687	510
1912	60.835	30,243,859	28,605,940	253,824	834,119	549,976	....
1913	57.791	29,681,975	28,105,505	825,108	248,992	502,370	....
1914	54.811	25,162,841	24,155,699	499,643	108,199	399,300	....
1915	49.684	24,746,534	24,280,366	223,939	....	242,229	....
1916	65.661	19,915,090	19,008,517	445,900	77,280	383,393	....
1917	81.417	19,401,893	18,327,258	....	10,000	1,064,635	....
1918	96.772	17,661,694	16,807,407	143,901	72,188	638,198	....
1919	111.122	11,214,317	10,314,689	171,278	4,586	723,764	....
1920	100.900	10,845,436	10,402,249	....	8,253	433,352	1,582
1921	62.654	8,261,931	7,673,535	1,101	328,886	258,292	117
	Total.....	322,707,550	310,687,281	2,942,613	3,055,627	6,135,884	30,046

Refineries.—The companies named hereunder with plants situated in southern Ontario, treat silver-cobalt ores, concentrates and residues:

REFINERS OF SILVER-COBALT ORES, 1921.

Name of Company.	Location of Works	P.O. Address
Deloro Smelting and Refining Co., Ltd....	Deloro..................	Deloro.
Coniagas Reduction Co., Limited.........	Thorold.................	St. Catharines.
Ontario Smelters & Refiners, Ltd.........	Welland.................	Welland.

The operations of the refining companies during 1921 are summarized in the figures given below. Apart from the silver recovered, from Cobalt and outlying silver areas, the marketed by-products had a value of $1,056,596. Metallic cobalt was sold for $3.00 per pound.

OPERATIONS OF SILVER-COBALT REFINERIES IN ONTARIO, 1921.

Schedule		Production	Marketed.	
		Quantity	Quantity	Value
				$
Ore and Concentrates treated	tons	2,047		
Residues treated	"	2,984		
Silver	fine ounces	3,709,693	3,884,683	2,668,107
Silver content of matte and residues	ounces		245,679	172,309
Arsenic, white	lbs.	3,509,921	2,982,525	233,763
Cobalt Oxide	"	216,875	165,554	354,418
Cobalt content of residues, marketed	"		55,826	49,724
Cobalt-nickel oxides, unseparated	"		105,675	113,865
Cobalt, Metallic	"	22,216	32,718	98,228
Nickel Oxide	"	66,382	12,396	3,830
Nickel Sulphate and Hydrate	"	5,503	5,503	393
Nickel, Metallic	"	39,485	10,973	3,442
Copper content of matte and sulphate	"		142,313	26,624
Total value of products marketed				3,724,703

The following figures have been compiled from information furnished by refineries in the United States which treated products from Ontario silver mines:—

	Quantity
Ore, Concentrates, etc., treated, tons	1,183
Silver recovered, ounces	562,160
Gold recovered, ounces	0.76
Copper recovered, lbs.	63,042
Lead recovered, lbs.	6,000

Shipments were consigned to the following:—

American Smelting and Refining Company, (Pueblo, Col., and Perth Amboy, N.J.).
Pennsylvania Smelting Co., (Carnegie, Pa.).
United States Metal Refining Co., (Chrome, N.J.).

Late in 1921 the new insecticide plant of the Deloro Smelting and Refining Company commenced operations, the principal products being arsenate of lime and arsenate of lead. The price of white arsenic (arsenious oxide) rose as high as 20 cents per pound in 1920 and fell as low as six cents in 1921. Arsenic is in demand, calcium arsenate particularly, as an antidote for the boll weevil in the cotton growing areas of the United States. Antimony was substituted for arsenic in glass manufacture during the war, owing to the latter being reserved for the manufacture of insecticides. Generally speaking, arsenic is preferred to antimony in the glass industry. In the Province the recovery of arsenic is entirely as a by-product in the treatment of silver-cobalt arsenides by southern Ontario refineries.

TABLE X.—DIVIDENDS AND BONUSES PAID BY SILVER MINING COMPANIES TO DECEMBER 31, 1921

Name of Company	Date of Incorporation	Authorized Capital	Capital Stock Issued	Par value per share	Dividends and Bonuses paid to end of 1920	Dividends and Bonuses paid during 1921	Total Dividends and Bonuses paid to 31st Dec., 1921	Date when last Dividend or Bonus was paid
		$	$	$ c.	$ c.	$ c.	$ c.	
Aladdin Cobalt Company, Limited	Aug. 23, 1912	500,000	500,000	5 00	75,000 00		75,000 00	April 30, 1917
Beaver Consolidated Mines, Ltd	Mar. 1, 1907	2,000,000	2,000,000	1 00	710,000 00		710,000 00	May 31, 1920
Buffalo Mines, Ltd., The (*a*)	April 27, 1906	500,000	500,000	50	2,787,000 00		2,787,000 00	May 28, 1914
Casey Cobalt Silver Mining Co., Limited	Dec. 19, 1906	100,000	100,000	1 00	203,249 33		203,249 33	Apl. 22, 1914
Cobalt Central Mines Co., Ltd	Dec. 13, 1905	5,000,000	5,000,000	1 00	192,845 00		192,845 00	Aug. 25, 1909
Cobalt Comet Mines, Ltd. (*b*)	April 16, 1913	1,000,000	1,000,000	1 00	230,000 00		230,000 00	April 1, 1915
Cobalt Silver Queen, Ltd	April 1, 1906	1,500,000	1,500,000	1 00	315,000 00		315,000 00	Dec. 31, 1908
Coniagas Mines, Limited, The	Nov. 24, 1906	4,000,000	4,000,000	5 00	10,740,000 00	200,000 00	10,940,000 00	Nov. 1, 1921
Crown Reserve Mining Co., Ltd	Jan. 16, 1907	2,000,000	1,999,957	1 00	6,190,849 00		6,190,849 00	Dec. 28, 1916
Foster Cobalt Mining Co., Ltd	Feb. 14, 1906	1,000,000	915,588	1 00	45,000 00		45,000 00	Jan. 1, 1907
Hudson Bay Mines, Ltd	July 16, 1909	3,500,000	3,200,050	5 00	778,909 42		778,909 42	Aug. 31, 1913
Kerr Lake Mining Company, Ltd. (*c*)	Aug. 9, 1905	40,000	40,000	100 00	8,865,000 00	610,000 00	9,475,000 00	Oct. 13, 1921
La Rose Mines, Ltd	May 31, 1908	1,500,000	1,500,000	1 00	7,505,409 56		7,505,409 56	April 20, 1918
McKinley-Darragh-Savage Mines of Cobalt, Ltd.	April 27, 1906	2,500,000	2,247,692	1 00	5,955,391 86		5,955,391 86	Oct. 1, 1920
Mining Corporation of Canada, Ltd	Nov. 23, 1916	8,300,250	8,300,250	5 00	5,498,874 97		5,498,874 97	Sept. 15, 1920
City of Cobalt Mining Co., Ltd. (*d*)	Oct. 5, 1906 Jan. 7, 1909	500,000 1,500,000	1,500,000	1 00	145,000 00		145,000 00	April 15, 1920
Cobalt Lake Mining Co., Ltd. (*d*)	Dec. 22, 1906	3,000,000	3,000,000	1 00	465,000 00		465,000 00	May 29, 1914

TABLE X.—*Continued.*

Name of Company	Date of Incorporation	Authorized Capital	Capital Stock Issued	Par value per share	Dividends and Bonuses paid to end of 1920	Dividends and Bonuses paid during 1921	Total Dividends and Bonuses paid to 31st Dec., 1921	Date when last Dividend or Bonus was paid
		$	$	$ c.	$ c.	$ c.	$ c.	
Cobalt Townsite Mining Co., Ltd. (*d*)	May 8, 1906	100,000	45,011	1 00	1,042,259 61	....	1,042,259 61	Nov. 11, 1914
Nipissing Mining Co., Ltd. (*e*)	Dec. 16, 1904	250,000	250,000	100 00	23,118,297 25	1,175,000 00	24,293,297 25	Oct. 20, 1920
Penn-Canadian Mines, Ltd. (*f*)	April 24, 1912	1,500,000	1,349,705	1 00	175,461 65	....	175,461 65	Sept. 10, 1917
Peterson Lake Silver-Cobalt Mining Co., Ltd	April 11, 1906	3,000,000	2,469,802	1 00	462,350 35	....	462,350 35	Jan. 2, 1917
Right of Way Mining Co., Ltd	July 13, 1906	500,000	499,518	1 00	324,643 93	....	324,643 93	Oct. 1, 1909
Right of Way Mines, Ltd	Sept. 11, 1909	2,000,000	1,685,500	1 00	252,825 00	....	252,825 00	Mar. 17, 1917
Seneca-Superior Silver Mines, Ltd	Sept. 29, 1911	500,000	478,884	1 00	1,579,817 20	....	1,579,817 20	Dec. 15, 1916
Temiskaming Mining Co., Ltd	Nov. 5, 1906	2,500,000	2,500,000	1 00	2,159,156 25	....	2,159,156 25	Jan. 31, 1920
Temiskaming and Hudson Bay Mining Co., Ltd.	July 10, 1903	25,000	7,761	1 00	1,940,250 00	....	1,940,250 00	Nov. 10, 1914
Trethewey Silver Cobalt Mines, Ltd	May 30, 1906 June 1, 1911	2,000,000	1,000,000	1 00	1,211,998 50	....	1,211,998 50	Jan. 2, 1919
Wettlaufer Lorrain Silver Mines, Ltd	Nov. 30, 1908	1,500,000	1,416,590	1 00	637,465 50	....	637,465 50	Sept. 22, 1913
Total	....	....	....	......	83,607,054 38	1,985,000 00	85,592,054 38	

(*a*) In 1917 the capital stock of the company was reduced from $1,000,000 to $750,000, in 1918 from $750,000 to $500,000, and on December 21, 1919, from $500,000 to $150,000, by returning to shareholders amounts equal to the reduction in capital, leaving 300,000 shares issued of 50 cents each. The mine was sold to the Mining Corporation of Canada, and operated by it in 1920 and subsequently.

(*b*) Cash assets amounting to $50,000 paid on April 27, 1917.

(*c*) In addition a return of capital amounting to $600,000 was made on July 3, 1919 to stockholders of the Kerr Lake Mines, Ltd.

(*d*) Mining Corporation of Canada, Limited, owns and operates the City of Cobalt, Cobalt Lake and Cobalt Townsite mines.

(*e*) Includes $16,288,297.25 paid in dividends by the Nipissing Mines Co. (the holding company) to the end of 1916.

(*f*) Paid out of capital $40,491.15 on Sept. 10, 1917, and an equal amount on April 24, 1918.

Nickel, Copper and the Platinum Metals

The nickel-copper industry, which developed gradually prior to the war and expanded greatly during that period, has been forced to greatly curtail operations or suspend them temporarily owing to the accumulated stocks of nickel and copper and lack of market for new production. If the disarmament programme is ratified the outlet for nickel in warship construction will be small. The present surplus stock will require time for absorption. A revival of the industry, therefore, depends on increased commercial activity and widened industrial uses for nickel and its alloys. Early in the year the British America Nickel Corporation closed down its mine, smelter and refinery, and was followed in September by the International Nickel Company of Canada. The Mond Nickel Company, which ships matte to its refinery in Wales, continued operations on a reduced scale throughout the year. The International Nickel Company is dismantling its refinery at Bayonne, New Jersey, and shipping part of the equipment to the refinery at Port Colborne, Ontario. Hereafter it is expected that the larger part of nickel-copper matte produced by this company will be treated in Canada at the Port Colborne refinery.

A few years ago engineers were confined to the use of steel, brass or bronze in the design and construction of plant and equipment, but research and experiment has changed this condition and now there are numerous alloys available, each with one or more outstanding properties which make it particularly desirable for special applications. The use of nickel has largely figured in these alloys and the one most widely used is the natural alloy called "Monel" metal, which is produced by the International Company directly from nickel-copper matte after the sulphur content has been eliminated. It is stronger than mild steel, retains its strength at high temperatures and has maximum resistance to corrosion and erosion. It resists crystallization and fatigue and will take a high nickel polish.

The production of ore during the year from the several mines was as follows:—

		Tons
British America Nickel Corporation:—		
Murray		45,366
International Nickel Company of Canada:—		
Creighton		54,471
Mond Nickel Company:—		
Levack, Garson, Worthington, Victoria No. 1 and Frood	157,317	
Bruce	5,439	
		162,756
Total		262,593

In Table XI, following, is indicated the course of the nickel industry during the last five years. That this metal takes on added importance during times of war is sufficiently shown by the fact that while in 1914 the quantity of ore smelted was 947,053 tons, it rose in 1918 to 1,559,892 tons, and fell again as noted in the table to 393,768 tons in 1921.

For the purpose of this table the nickel and copper in matte exported in 1921 were valued at 20 cents and 10 cents per pound, respectively.

TABLE XI.—NICKEL-COPPER MINING AND SMELTING, 1917-1921.

Schedule		1917	1918	1919	1920	1921
Ore raised	tons	1,536,828	1,643,040	614,955	1,200,830	262,593
Ore smelted	"	1,453,661	1,559,892	754,567	1,087,531	393,768
Bessemer matte produced	"	78,897	87,184	42,735	57,938	19,498
Nickel contents of matte	"	41,887	45,886	22,035	30,615	9,128
Copper contents of matte	"	21,197	23,843	12,099	16,021	6,323
Matte exported*	"	....	....	25,207	40,367	10,466
Matte refined in Canada	"	....	5334	10,911	17,297	5,558
Men employed	No.	3,356	3,145	2,536	3,258	1,895
Wages paid		$5,570,587	7,861,773	3,382,154	5,555,469	1,557,696

*All matte was exported prior to 1918 when refining in Canada began at Port Colborne, Ontario.

The following figures summarize the operations of the International Nickel Company of Canada's refinery at Port Colborne and that of the British America Nickel Corporation at Deschênes on the Ottawa river:—

TABLE XII.—NICKEL-COPPER REFINING, 1921.

Schedule		Quantity	Value
			$
Matte treated	tons	5,558	....
Nickel Oxide marketed	lbs.	1,389,623	281,561
Metallic Nickel recovered	"	5,419,174	1,821,917
Blister Copper and Electrolytic Copper recovered	"	2,926,407	330,084
Gold recovered*	ounces	2,358	48,637
Silver recovered*	"	49,515	30,953
Platinum metals recovered*	"	13,418	862,034
Employees	No.	454	....
Wages paid		....	$ 367,216

*Includes recoveries by the Mond Nickel Company at Clydach in Wales

Returns by refineries treating Ontario silver ores show a recovery of 205,355 pounds of copper. In addition 10,973 pounds of nickel and 12,396 pounds of nickel oxide were marketed.

The average New York price of electrolytic copper was 12.502 cents per pound for the full year, as compared with 17.456 cents in 1920.

Platinum Metals.—Ontario nickel-copper ores of the Sudbury area contain the precious metals, gold, silver and metals of the platinum group. The latter may be divided into two main sub-groups on a specific gravity basis as follows:

Metal	Specific Gravity	Metal	Specific Gravity
Palladium (Pd.)	12.16	Platinum (Pt.)	21.40
Rhodium (Rh.)	12.44	Iridium (Ir.)	21.42
Ruthenium (Ru.)	12.10	Osmium (Os.)	22.50

In the last annual report figures were given for 1920 showing platinum metals produced in Canada, United States and Great Britain from the refining of Ontario nickel-copper matte. Complete figures for 1921 are given on next page.

Precious metals cement was shipped by the International Nickel Company of Canada to the United States for further refining along with similar recoveries made at the Bayonne, N.J., plant.

Production of platinum metals by the British America (reporting for the first time), International and Mond companies follows:—

	Platinum	Palladium	*Iridium, etc.	Total
Quantity . . . . Troy ounces	5,412	7,729	277	13,418
Value . . . . $	402,508	446,588	12,938	862,034

*Iridium and rhodium in small amounts was grouped by the Mond Company with gold and is not recorded in the above figures.

At the Bayonne plant 2,217 tons of matte were treated, although the matte bears little relation to precious metals recovered as the residues treated accumulate over irregular periods. In the figures above given platinum metals contained in precious metals cement shipped from Port Colborne to the refinery of the International Nickel Company, at Bayonne, N.J., are included with recoveries from the matte treated in the United States.

Average prices as reported by the U.S. Geological Survey were platinum $75 per ounce troy, palladium $59, iridium $86 (containing five per cent. platinum.)

Iron Ore

The only iron ore raised in 1921 was 42,198 tons of siderite from the Magpie mine of the Algoma Steel Corporation. Total shipments of ore and briquettes from the three properties noted below were 58,499 tons worth $227,134. Of the total shipments only 100 tons worth $459 were consigned to points other than Ontario blast furnaces. These consisted of 78 tons of briquettes by Moose Mountain, Limited, and a trial shipment of 22 tons of hematite from the Wallbridge mine, near Madoc. From the Magpie mine, which closed down in March, the Algoma Steel Corporation of Sault Ste. Marie, received 58,399 tons of roasted siderite.

During the year repairs to the blast furnace at Port Arthur were made with a view to placing it in operation again to handle ore from a property near the Ontario-Minnesota boundary, which is being developed by the Palatine Mining Company. Some work was done at Atikokan, 142 miles west of Port Arthur, to more fully determine the quality and extent of certain ore bodies.

Following is a list of iron mines from which shipments were made during the year:

SHIPPERS OF IRON ORE, 1921.

Company or Firm.	Mine.	Location.	Kind of Ore.	P.O. Address of Company.
Algoma Steel Corporation, Limited	Magpie	Algoma dist.	Siderite	Sault Ste. Marie.
Moose Mountain, Ltd. . . .	Moose Mount'n	Hutton tp. (Sudbury dist.)	Magnetite	Sellwood.
Wallbridge, Mrs. T. C. . .	Wallbridge	Madoc tp.	Hematite	Madoc.

Pig Iron, Steel and Ferro-Alloys

The iron and steel industry experienced depression throughout the greater part of the year. Prices returned practically to pre-war levels. Blast furnaces were operated for different periods by the Algoma Steel Corporation, Steel Company of Canada, Canadian Furnace Company and the Midland Iron and Steel Company. In Table I Ontario is credited with the proportional output from domestic ore, or 13.4 per cent. of the total pig iron made.

The average Valley quotation for the year was $21.71 per gross ton for basic pig iron. In the *Iron Age*, issue of December 8, 1921, the cost per gross ton (2,240 pounds) of producing pig iron in the three principal iron centres of the United States was given as follows: Pittsburgh, $19.29; Chicago, $19.54 and Birmingham, $15.58.

The Algoma Steel Corporation produced 9,750 tons of spiegel valued at $436,559. Electro-metals, Limited, of Welland, produced 12,209 gross tons of ferrosilicon valued at $561,720. For this output of several grades ranging from 15 to 80 per cent. ferro the following raw materials were used; 370 gross tons of pyrite cinder from the United States; 1,315 tons of steel turnings and 12,083 tons of Killarney quartzite containing 99 per cent. silica.

BLAST FURNACES IN ONTARIO FOR THE PRODUCTION OF PIG IRON.

Company	Location	Furnaces		Remarks
		No.	Daily capacity, gross tons	
Algoma Steel Corporation, Ltd....	Sault Ste. Marie..	4	1,450	Active.
Atikokan Iron Company.........	Port Arthur.....	1	175	Idle since 1911.
Canadian Furnace Co., Ltd.......	Port Colborne....	1	325	Active.
Canadian Steel Corporation, Ltd..	Ojibway (near Windsor)......	2	1,100	Under construction.
Midland Iron and Steel Co., Ltd..	Midland.........	1	120	Idle since Feb., 1921.
Parry Sound Iron Co., Ltd.......	Parry Sound.....	1	90	Idle since Oct. 1., 1919.
Standard Iron Co., Ltd..........	Deseronto.......	1	60	Idle since June 9, 1919.
Steel Company of Canada, Ltd...	Hamilton........	2	750	Active.

Note.—The first and last mentioned produce open-hearth steel as well as pig iron.

IRON BLAST FURNACES IN OPERATION, 1921.

Name of Company	Furnaces		Fuel used.	Location.
	Number.	Ave. days operated.		
Algoma Steel Corporation, Ltd....	4	358	Coke.........	Sault Ste. Marie.
Canadian Furnace Company, Ltd..	1	114	Coke.........	Port Colborne.
Midland Iron and Steel Co., Ltd..	1	41	Coke.........	Midland.
Steel Company of Canada, Ltd....	2	365	Coke, coal and gas.........	Hamilton.

The following table gives particulars of the iron and steel-making industry of the Province for the last five years:—

TABLE XIII.—IRON AND STEEL STATISTICS, 1917-1921.

Schedule.	1917	1918	1919	1920	1921
Ontario ore smelted.......short tons	94,318	99,852	97,514	152,176	126,653
Foreign ore smelted....... "	1,221,881	1,400,085	1,201,834	1,341,661	818,749
Limestone for flux........ "	319,535	405,683	343,907	349,960	221,761
Coke.................. "	723,657	869,729	736,872	818,698	420,358
Charcoal......................bush.	1,288,390	....	177,795	....	....
Pig iron produced........short tons	691,233	751,650	623,586	748,173	494,901
Value of pig iron produced........$	14,201,695	20,522,356	16,010,537	21,652,308	11,856,352
Steel made.............short tons	862,504	881,509	616,251	707,692	932,473
Value of Steel made.............$	22,179,982	28,792,361	17,913,263	26,366,524	15,861,635

Lead

The only producing lead mine in Ontario is that of the Kingdon Mining, Smelting and Manufacturing Company, Ltd., which also operates a smelter at Galetta, on the Ottawa river. With the exception of a small recovery of lead in United States refineries from Ontario silver ores, the total sales of 3,576,222 pounds worth $191,113 were shipped from Galetta. During the year 33,557 tons of ore were mined and concentrated. Shipments of pig lead were made to Canadian points. The average New York price for the year was 4.545 cents per pound, the lowest since 1914. Prices at Montreal, the main Canadian market, are generally higher than in the United States, the Montreal average price being 5.742 cents per pound in 1921 and the Toronto price 5.849 cents.

About 1,500 tons of lead slag, a residue from the Newnan hearth, was on hand at Galetta at the end of the year. A small grab sample assayed 40 per cent. lead and 10 per cent. zinc; and a similar flue dust sample gave 70 per cent. lead and three per cent. zinc. The erection of a small blast furnace is under consideration for further treating slag and flue dust. Zinc blende is recovered from concentrating tables and bagged for future use. A description of mine and smelter appeared in the *Canadian Mining Journal,* issue of February 24, 1922.

NON-METALLIC MINERALS

Actinolite

Shipments during the year were seventy-eight tons, valued at $975. There is only one producer in the Province, namely, the Actinolite Mining Company, with a mill at the village of the same name, situated about four miles north of Tweed station on the Canadian Pacific railway. The mineral is mined in the townships of Kaladar and Elzevir, Hastings county, and the head office of the company is Bloomfield, New Jersey. The product, which is fibrous in nature, is used principally for roofing purposes, as an ingredient in coal-tar compounds.

Barite (Barytes)

There was a production by H. C. Bellew of 6 Saint Sacrament St., Montreal, Que., of approximately 200 tons of barite or heavy spar. No shipments were made from the deposit, which is located on lot 20, concession X, township of North Burgess, Lanark county.

Calcite and Dolomite

There is a growing market for ground calcite and dolomite in the paint and other trades. From Palmerston township in Frontenac county, T. B. Caldwell, of Perth, shipped seventy tons of pure calcite to paint manufacturers, for experimental use.

A dolomite deposit was opened up at Baptiste lake, Herschel township, by the Ontario Dolomite Manufacturing Company, Ltd. No shipments to the Toronto grinding plant of the company were made in 1921. This mineral is coming into use for the manufacture of artificial stone.

Corundum

The entire production of this natural abrasive, 403 tons, valued at $55,965, was the output of Corundum, Limited, operating at Craigmont. During the year 11,256 tons of tailings from lot 4, concession XVIII, Raglan township, were milled. Shipments were made in "grain" form. Artificial abrasives are replacing corundum for many purposes.

Feldspar

For several years prior to 1920, Ontario's output of feldspar ranged from 12,000 to 20,000 tons per annum. In 1920 shipments jumped to 37,335 tons, worth $268,295, due to an increased demand by United States pottery and porcelain manufacturers. In the second half of 1921, shipments fell off, particularly those of second-grade spar. Prices dropped during the year from $9.00 per ton f.o.b. cars to $7.00 for No. 1 spar and from $6.00 to $5.00 per ton for No. 2. The bulk of the supply is quarried in Frontenac and Hastings counties. Shipments go chiefly to the pottery and porcelain centres of New Jersey and Ohio. The Feldspar Milling Company of Toronto, with plant on Don Esplanade, has a grinding capacity of about 6,000 tons per annum. The new plant of the

Frontenac Floor and Wall Tile Co., completed in December, is capable of handling 1,500 tons per year, and can be doubled by adding another pebble mill. About 2,250 tons were ground in Ontario in 1921 by the Toronto firm. Total shipments in 1921 were 19,887 tons, worth $170,133, which includes both crude and ground spar.

There is a growing demand for pink spar, crushed to pass one-quarter inch mesh and retained on one-eighth inch mesh, for use as a "stucco dash." Second-grade spar, including chips, may be marketed in this form.

Shippers in 1921 are noted hereunder:

FELDSPAR SHIPPERS, 1921.

Name.	Location of Deposit.	P.O. Address.
Canadian Non-Metallic Minerals, Ltd	Dickens tp	207 James St., Montreal
Dillon and Mills	Lot 23, Con. VI, Monteagle tp.	Hybla.
Eureka Flint and Spar Co	Lot 16, Con. XI, Portland tp	Verona and Trenton, N.J.
Federal Feldspar, Ltd	Lot 25, Con. III, Bedford tp	46 Elgin St., Ottawa.
Feldspar Quarries, Ltd	Portland tp	60 Front St. E., Toronto.
Feldspars, Limited	Richardson Mine, Bedford tp	103 Bay St., Toronto.
Gardner Feldspar Co	Lots 1 and 2, Con. XI, Loughborough tp	Hartington.
Industrial Minerals Corp. of Canada, Ltd	Lots 29 and 30, Con. XV, Monmouth tp	805 Bank of Hamilton Bldg., Toronto.
International Feldspar Co., Ltd.	Lot 2, Con. III, Bedford tp	214 Humber Bldg., Highland Park, Detroit, Mich.
McConnell Consolidated Mines, Ltd	Lot 3, Con. VIII, Bathurst tp (Kirkham quarry)	Perth, Ont.
North American Feldspar, Ltd.	Pickins mine, Gooderham	24 Orchard Park Rd., Toronto.
O'Brien and Fowler	Lots 5 and 8, Cons. II and III, March tp	17 Beech St., Ottawa.
Orser-Kraft Feldspar, Ltd	S. Sherbrooke, Bathurst and Drummond tps	Box 366, Perth.
Orser and Wilson	Lot 11, Con. IX, Loughborough tp	Perth, Ont.
Provincial Feldspar Co	Lot 15, Con. VI, S. Sherbrooke.	33 Richmond St. W., Toronto.
Rock Products Company, The.	Lot 10, Con. VI, Bathurst tp (Jas. Keays' quarry).	1154 Nicholas Bldg., Toledo, Ohio.
Storrington Feldspar Company, Ltd	Lots 8, 9, 10, Con. XIII, Storrington	C. G. Walton, Sec.-Treas., Elgin.
Verona Mining Co	Lots 18, 19 and pt. 20, Con. VII, Monteagle	Hybla and 404 Harrison Bldg., Philadelphia, Pa.

Fluorspar

The output of this mineral declined from 3,704 tons in 1920 to 115 tons, worth $1,744, in 1921. Curtailed operations in the steel industry was the primary cause of this situation. The maximum output was in 1918, when 7,286 tons were marketed.

There were only two shippers in 1921, as follows:

FLUORSPAR SHIPPERS, 1921.

Name.	Location.	Address.
Cross and Wellington.........	Lot 11, Con. XIII, Huntingdon	Madoc.
Herrington and Herrington....	Lot 2, Con. XII, Madoc......	Madoc.

Graphite

The graphite industry was stagnant during the year, only one operator, the Black Donald Graphite Company, reporting shipments. The Timmins Graphite Mines treated a small quantity of crude ore, and the two companies had on hand at the end of the year 614 tons of unsold product. Shipments by the Black Donald Company were 21½ tons of flake and 341½ tons of dust, or a total of 363 tons, valued at $23,273.

GRAPHITE OPERATORS, 1921.

Company.	Location of Mine.	P.O. Address.
Black Donald Graphite Co., Ltd.	Brougham tp., Renfrew county	Calabogie.
Timmins Graphite Mines, The.	N. Burgess tp., Lanark county	Stanleyville.

Artificial graphite, a product of the electric furnace, is manufactured by the Acheson Graphite Company of Niagara Falls, Ontario. The output in 1921 was 376,508 pounds.

Gypsum

The Ontario Gypsum Company is the only operating Company in the Province, with mines and mills at Caledonia and Lythmore, in Seneca and Oneida townships, Haldimand county, and head office at Paris. When the Crown Gypsum Company's mill at Lythmore was purchased, a new mine at Lythmore, about five miles east of Hagersville on the Michigan Central railway, was opened up and the old Martindale mine abandoned. The company mines, crushes, grinds and calcines gypsum; manufactures wall plaster, plaster of Paris and other gypsum products. Crushed and fine-ground gypsum marketed in 1921, totalled 37,751 tons, calcined gypsum 15,020 and calcined gypsum used in manufactured products, 32,019 tons; a total of 84,765 tons, valued at $133,053. Gypsum products, including wall board and fireproof blocks, are finding an increasing market in the building industry.

The Emley patented process of manufacturing plastic gypsum has been adopted by this company in the Caledonia mill, and similar machinery is being installed at Lythmore. In the new process plaster of Paris is ground in a ball mill, thereby driving out the moisture of crystallization. Recombining while still in the mill has the effect of making hardwall plaster denser and more plastic, giving it the property of easier spreading and making it capable of carrying more sand. This process is being introduced rapidly in the United States, and means a general improvement in the plaster industry. The Ontario Gypsum Company was the first company in Canada to adopt the Emley process, patented by W. E. Emley, of the United States Bureau of Standards, Washington, D.C.

Iron Pyrites

The iron pyrites or sulphur ore industry in Ontario, in 1921, reflects the general economic depression, and the outlook for this mineral is not bright. There were mined during the year a total of 26,107 tons, of which 19,375 tons, worth $91,604, were shipped. A final clean up of the Wawa (Helen mine) stock pile was made by the Algoma Steel Corporation and the ore shipped to Sault Ste. Marie. Ontario shipments contained thirty-eight per cent. sulphur, with the exception of the sulphide deposit of the Nichols Chemical Company, which assayed 33.6 per cent. sulphur.

Native sulphur from the "Gulf" states of Texas and Louisiana, made available more cheaply than pyrites could be, is supplanting the latter on the North American continent. It also finds sale on the European market in competition with Sicilian sulphur. The only place where Spanish pyrites competes successfully on the United States market is on the Atlantic seaboard, and less than one quarter of the pre-war quantity of iron pyrites is being imported into the United States. In fact, domestic production of iron ppyrites in the United States meets its chief competition from American native sulphur, rather than from imported pyrites.

Following is a list of pyrite shippers in 1921:

IRON PYRITES SHIPPERS, 1921.

Name of Owner, Firm or Company.	Location or Name of Mine.	P.O. Address of Manager, etc.
Algoma Steel Corporation, Limited	Helen	Sault Ste. Marie.
Grasselli Chemical Co	Caldwell	Flower Station.
Nichols Chemical Co., Limited, The	Sulphide Vermillion Lake	Sulphide. Northpines.

Mica

The industry, which is centred in Eastern Ontario, was inactive during most of the year. Shipments totalled 218 tons, including 86 tons of scrap mica. The total value of all grades was $28,891, as compared with $54,169 in 1920, when 719 tons were marketed. Scrap mica is now being concentrated and ground to various degrees of fineness for a wide variety of uses, including the rubber trade, but principally for the manufacture of prepared roofing materials.

The Loughborough Mining Company, operating the Lacey mine at Sydenham, Frontenac county, was the largest shipper of rough-cobbed mica.

Prices for thumb-trimmed mica, depending on quality, ranged as follows:

Size.	Price per lb.	Size.	Price per lb.
1″ x 1″	7c. to 17c.	2″ x 4″	60c. to 80c.
1″ x 2″	13c. to 17c.	3″ x 5″	$1.35 to $1.50
1″ x 3″	20c. to 35c.	4″ x 6″	$2.00 to $2.25
2″ x 3″	40c. to 60c.		

Following is a list of mica shippers:

MICA SHIPPERS, 1921.

Name of Owner or Producer.	Location or Name of Mine.	P.O. Address of Manager, etc.
Elliott, Wm. M.	Mica lake, Butt tp.	3433 Walnut St., Chicago, Ill.
Green, George	Bedford tp.	Perth Road.
Kent Bros. and Estate J. M. Stoness	Bedford tp.	Kingston.
Kingston and Perth Mining Co.	North Burgess tp.	Kingston.
Loughborough Mining Co., Ltd.	Loughborough tp.	Sydenham.
McLaren, W. L.	North Burgess tp.	Perth.
Trousdale, Jas.		Sydenham.

Mineral Waters

Statistics of production and valuation are not entirely satisfactory, for the reason that in many cases mineral waters are shipped from the springs in barrels or other containers to bottling works, and only a nominal valuation is given for such shipments. In other cases a much higher valuation is placed on the product where bottling works are located at the springs. The record does not include consumption of mineral waters for medicinal or bathing uses in connection with sanitaria, such as those located at St. Catharines and Preston Springs. Shipments reported were 308,647 Imperial gallons, valued at $14,438.

Below are tabulated records of shipments since reports were first received in 1918:

	1918	1919	1920	1921
Imperial gallons	208,498	276,833	127,150	308,647
Value	$133,808	$19,290	$15,059	$14,438

Natural Gas

A complete discussion, "Natural Gas in 1921," by R. B. Harkness, Natural Gas Commissioner, appears as Part V, Volume XXXI, Report of the Ontario

Department of Mines. Production was 8,532,234,000 cubic feet, valued by the producers at $2,975,502. The average retail price in 1921 was about 45 cents per M. cubic feet.

Peat

Shipments for the year from the Alfred bog, east of Ottawa, where experimental operations are being carried on jointly by the Ontario and Federal governments, were 1,666 tons, valued at $7,800. About 4,000 tons were manufactured, but all fuel not sold was lost in November, by a fire which destroyed the storage pile.

The work carried on at Alfred is primarily an investigation with the object of developing a type of machinery suitable for peat fuel manufacture by the air-drying method. In 1921 the plant was in operation for 107 days, or about the average period feasible in our climate. For fuller description of the plant see progress statement of the Joint Peat Committee, issued as Part IV, Volume XXXI, Report of the Ontario Department of Mines.

Petroleum

A report on "Petroleum in 1921," by the Natural Gas Commissioner, appears in Vol. XXXI, Part V. The following statistical tables, which are repeated here for convenience, are taken from the above-mentioned report.

CRUDE PETROLEUM PRODUCTION (1), BY FIELDS, 1917-1921.

Field.	1917	1918	1919	1920	1921
	Bbls.	Bbls.	Bbls.	Bbls.	Bbls.
Petrolia and Enniskillen	74,267	65,467	70,087	65,082	68,484
Oil Springs	46,902	44,671	45,245	39,388	40,967
Moore township	6,282	6,367	4,029	7,036	7,536
Sarnia township	4,494	3,438	4,259	3,495	4,068
Plympton township	579	412	560	531	481
Bothwell	29,682	29,116	29,425	25,563	26,877
Dover, West Tilbury	10,041	25,228	16,705	12,171	7,473
Tilbury, East			1,660	623	1,003
Raleigh township	....	....	....	(2)	3,320
Dutton	2,941	1,875	1,272	837	....
Onondaga township	383	1,186	197	341	566
Belle River	....	447	....	....	....
Mosa township	20,999	108,988	45,860	24,063	10,764
Thamesville	6,420	1,565	801	1,131	1,320
Total Production ... Bbls.	202,990	288,760	220,100	181,750	172,859
Value ... $	475,000	781,097	632,789	724,145	466,716
Average price per Bbl. (3) ... $	2.34	2.70½	2.87½	3.98½	2.68½

---

(1) Figures supplied by J. C. Waddell, Supervisor of Petroleum Bounties, Petrolia.

(2) Production for 1920 in Raleigh township was included with that of Dover West.

(3) A bounty of 52½ cents per barrel (35 Imperial gallons), or a total of $90,748.78, was paid in addition by the Federal Government under The "Petroleum Bounty Act."

Four refineries operated in the Province in 1921, as noted hereunder:

PETROLEUM REFINERIES, 1921.

Company.	Location of Refinery.	Days Operated	Head Office Address.
British American Oil Co., Ltd.	Toronto, Cherry St.	314	Toronto, Royal Bank Bldg.
Canadian Oil Companies, Limited	Petrolia	309	Toronto, Excelsior Life Bldg.
†Cities Service Oil Co., Ltd.	Wallaceburg	306	Wallaceburg.
Imperial Oil, Limited	Sarnia	312	Sarnia.

†This company took over the Great Lakes Oil Company's refinery on Mar. 1, 1921.

The following table, summarized from annual reports of the Ontario Department of Mines for the years 1907-1920 and table supplied by the Dominion Bureau of Statistics for 1921, shows refinery operations for the past five years:

CRUDE PETROLEUM AND REFINERY STATISTICS, 1917-1921.

Schedule.	1917	1918	1919	1920	1921
Crude petroleum production					
Imp. gals.	7,107,700	10,106,615	7,703,515	6,361,234	6,050,062
[1]Value " $	475,000	781,097	632,789	724,145	559,198
American Crude, distilled,					
Imp. gals.	122,436,923	137,065,788	141,157,309	148,540,511	150,692,113
Value " $	9,236,033	12,612,882	12,486,174	20,102,784	14,537,339
Canadian Crude, distilled,					
Imp. gals.	8,122,063	9,513,222	7,693,385	6,402,118	5,880,086
Value " $	559,435	781,703	661,927	769,775	500,418
Per cent. of total	6.22	6.49	5.17	4.13	3.75
Products:					
Illuminating oil ... Imp. gals.	40,195,774	36,211,715	34,800,233	33,897,891	29,774,134
Value " $	3,457,817	4,239,816	5,073,647	6,331,706	3,335,200
Lubricating oil .... Imp. gals.	12,288,466	12,595,305	12,501,385	13,804,074	13,848,721
Value " $	1,586,270	2,118,002	2,293,640	3,276,569	2,351,975
Benzine, Naphtha, Gasoline .... Imp. gals.	34,611,056	39,156,447	44,625,590	47,418,420	51,033,337
Value " $	8,292,828	10,244,328	11,677,077	14,485,935	12,655,244
[2]Gas and Fuel oil, Tar, Imp. gals.	39,815,106	40,949,358	40,581,499	45,025,050	44,364,794
Value " $	2,671,414	2,943,503	2,265,457	5,486,636	2,130,685
Paraffin Wax and Candles, lbs.	12,649,553	13,650,128	10,903,202	10,398,127	10,777,994
Value " $	908,996	1,148,726	1,044,798	973,805	310,267
Employees .... Ave. No.	1,289	1,312	1,580	1,736	1,560
Wages paid .... $	1,259,344	1,486,677	2,045,072	2,695,507	2,176,700

[1] The value includes bounty paid to producers.

[2] Figures for 1921 do not include Tar product, which was 18,971,400 pounds, with selling value of $142,285.00.

Quartz and Silica Brick

Production for the year was 72,068 tons, valued at $220,806. Quartz or silica is used in the smelting of nickel-copper ores in the Sudbury area, in the manufacture of ferro-silicon, for making silica brick and other uses requiring smaller quantities. The nickel companies supply their own requirements. Feldspar producers frequently recover quartz, which, if sufficiently pure, is shipped as a by-product. The Algoma Steel Corporation manufactured 1,094,069 silica brick during the year, using the same for lining blast furnaces.

The following operated quarries and made shipments in 1921:

QUARTZ SHIPPERS, 1921.

Name of Owner, Firm or Company.	P.O. Address of Operator.	Location of Quarry.
Algoma Steel Corporation	Sault Ste. Marie	A. C. Ry. (Deroche tp.).
Eureka Flint and Spar Company	Verona	Portland tp.
International Nickel Co. of Canada	Copper Cliff	Dill tp.
Mond Nickel Company	Coniston	Neelon tp.
Orser-Kraft Feldspar Company	Perth	Bathurst, Drummond and S. Sherbrooke tps.

Salt

Production of salt was well maintained in 1921, but brine for chemical plants was not as extensively used as in 1920. The ten salt plants operated are all situated in the south-western peninsula of the Province, between Kincardine on Lake Huron and Amherstburg on the Detroit river. Brine with salt equivalent of 50,529 tons was used in the chemical plant of Brunner Mond, Canada, Limited, at Amherstburg, and that of the Canadian Salt Company, Limited, at Sandwich. Chemicals produced include soda ash by the former company, while the latter turns out caustic soda and bleaching powder.

The following tables gives details of Ontario's salt industry over a five-year period:

SALT STATISTICS, 1917-1921.

Schedule.		1917	1918	1919	1920	1921
Land	tons.	2,093	2,041	1,720	2,054	2,599
Coarse	"	32,236	25,232	35,150	28,709	28,925
Fine	"	56,028	53,908	47,571	39,663	36,074
Table and Dairy	"	34,251	34,324	34,396	42,474	40,931
Pressed Blocks	"	....	....	....	....	2,966
Brine (salt equivalent)	"	14,301	16,221	29,275	93,712	50,529
Total Sold or Used	"	138,909	131,726	148,112	206,612	161,024
Value of "	$	1,047,707	1,287,039	1,395,368	1,544,867	1,643,527
Employees*	No.	238	312	296	338	264
Wages	$	234,925	275,842	319,463	442,004	311,205

*Employees of chemical works are not included.

The list of companies producing brine or salt in 1921 was as follows:

SALT COMPANIES, 1921.

Name of Owner, Firm or Company.	Location of Wells or Works.	P.O. Address of Manager, etc.
Brunner, Mond Canada, Limited	Amherstburg*	Amherstburg.
Canadian Salt Company, Limited, The	Windsor Sandwich*	Windsor.
Dominion Salt Company, Limited, The	Sarnia	Sarnia.
Elarton Salt Works Co., Ltd.	Warwick	Watford. R.R. No. 5.
Exeter Salt Works Company, Limited	Exeter	Exeter.
Goderich Salt Co., Limited	Goderich	Goderich.
Ontario People's Salt and Soda Co., Ltd.	Kincardine	Kincardine.
Western Canada Flour Mills Co., Ltd	Goderich	Goderich.
Western Salt Company, Limited	Courtright	Courtright.
Wingham Salt Works (Young Estate)	Wingham	Wingham.

*Chemical works using salt brine as raw material.

Talc and Soapstone

Shipments of crude and ground talc fell off from 21,411 tons, valued at $162,784, in 1920, to 9,967 tons, worth $140,390, in 1921. There was a larger proportion of ground talc sold than in 1920, as the valuation figures indicate. The American Talc Corporation early in the year turned over its mill and the Connolly mine to the Asbestos Pulp Company, Limited. The latter Company operated to September 1st, when the plant was shut down. The Henderson mine, an adjacent property, delivered its entire output of 7,916 tons of crude talc to the mill of Geo. H. Gillespie and Company, Limited. Ground talc prices ranged from $8.00 to $22.00 per ton, depending on grade. The entire industry is centred at Madoc in Hastings county.

The United States is the largest talc-producing country. Uses of ground talc in 1921, in order of consumption, as reported by the United States Geological Survey, were as follows: paper, 38 per cent.; paint, 23; roofing, 18; rubber, 9½; textile, 4; toilet powder, 2½; other uses, 5 per cent.

A deposit of soapstone has been located near Wabigoon station, District of Kenora. It closely resembles the Alberene stone of Virginia in mineral composition. There is no record to date of soapstone of domestic origin having been used in a commercial way in this Province.

TALC STATISTICS, 1917-1921

Schedule	1917	1918	1919	1920	1921
Crude talc shipped ... tons.	2,398	1,044	1,644	5,228	9,967
Ground talc shipped ... "	13,678	16,421	15,927	15,131	
Total value shipment ... $	179,554	246,691	240,339	306,319	140,390
Employees, mine and mill ... No.	56	43	87	60	30
Wages paid ... $	49,734	41,936	76,384	77,818	41,978

The following companies and firms were engaged in the mining and milling of talc during 1921:

TALC OPERATORS, 1921

Firm or Company	Location of Mine or Works	Address of Manager, etc.
*Henderson Mines, Limited	Huntingdon tp.	Madoc.
Geo. H. Gillespie and Company, Ltd.	Madoc (grinding mill)	Madoc.

*The Henderson mine was operated under lease by Henderson Mines, Limited, the product going to the mill of Geo. H. Gillespie and Company.

STRUCTURAL MATERIALS

During 1921 wholesale prices of commodities in general declined 27 per cent. from those obtaining at the close of 1920, or a total decline of nearly 46 per cent. from the peak of May, 1920. This unprecedented fall in prices, both as to swiftness and severity, naturally had a depressing effect on general business. The first seven months of the year were marked by the greatest decline, while December recorded a reaction as shown by a small advance in general commodity prices.

Building construction naturally responded to the decline in prices of materials, but still there was hesitation to launch large building programmes in the fear that the downward trend might continue. On the other hand it was necessary to commence work on projects that had been long delayed by high construction costs, both as to materials and labour, which prevailed throughout the greater part of 1920. Building permits in 25 Ontario cities as reported by the *Labour Gazette* totalled $49,276,999 in 1921, as compared with $51,783,660 in 1920.

Clay Products

Many of the smaller and less-efficient clay-working plants which closed down during the war may not reopen, as the present-day tendency is towards larger and better-equipped plants. The Canadian National Clay Products Association is doing much in the way of standardization and towards improving conditions in the industry. The average price of common brick was $7.96 per M in 1915, $13.92 in 1919, $17.74 in 1920 and $17.68 in 1921. A decrease in fuel and labour costs permitted a small reduction in brick prices.

SEWER PIPE AND POTTERY WORKS, 1921.

Name of Company	Location of Plant and P.O. Address of Manager, etc.
SEWER PIPE.	
Dominion Sewer Pipe and Clay Industries, Ltd	Swansea.
Hamilton & Toronto Sewer Pipe Co., Ltd	Hamilton.
Ontario Sewer Pipe & Clay Products, Ltd.	Mimico.
POTTERY.	
R. Campbell's Sons	100 Locke St. South, Hamilton.
Davis & Son, John	601 Merton St., Toronto.
Foster Pottery Company	Main St. West., Hamilton.

The table which follows gives the value of clay products marketed for the last pre-war year and subsequently:

VALUE OF CLAY PRODUCTS SOLD OR USED, 1913-21

Year	Brick		Pottery	Drain Tile	Sewer Pipe	Total
	Common	Pressed Fancy, Building Tile, etc.				
	$	$	$	$	$	$
1913	3,283,894	1,162,860	52,875	292,767	600,297	5,392,693
1914	2,336,207	894,381	25,720	277,530	571,750	4,165,597
1915	763,591	375,865	49,387	321,253	361,283	1,871,379
1916	509,559	495,895	87,025	275,471	216,749	1,584,699
1917	713,824	776,302	94,501	546,040	379,923	2,509,590
1918	665,454	592,286	88,275	309,899	362,536	2,018,450
1919	1,966,711	726,500	119,551	354,700	609,100	3,776,562
1920	2,209,265	1,178,656	127,049	359,373	860,811	4,735,154
1921	2,025,643	2,059,606	69,984	397,104	939,463	5,094,696

Following is a list of 106 brick and tile operators who reported an output in 1921:—

BRICK AND TILE PLANTS, 1921.

Name.	Address.	Product.
Atlas Brick Co., Ltd.	Toronto, 30 Toronto St.	Pressed Brick.
Alvinston Brick and Tile Co., Ltd.	Alvinston	Common Brick, Hollow Blocks and Tile.
Baird & Son, H. C.	Parkhill	Brick and Tile.
Baker, Geo. C.	Arnprior	Brick and Tile.
Bannerman, Geo., Jr.	Greenock, R.R. No. 1	Common Brick and Tile.
Barnhardt, W. H.	Stratford	Brick and Tile.
Bechtel, B. E.	Waterloo	Brick.
Bennett, Robert	Dunnville, Box 21	Brick and Tile.
Booth Brick and Lumber Co., Ltd.	New Toronto	Pressed Brick.
Brampton Pressed Brick Co.	Brampton	Pressed Brick and Tile.
Broadwell & Son, B.	Kingsville	Tile, Brick and Blocks.
Brownscombe, H.	Cargill	Brick and Tile.
Buck, J. L.	Port Rowan	Brick, Tile and Blocks.
Canadian General Electric Co., Ltd.	Toronto, King St., W.	Pottery.
Canadian Pressed Brick Co., Ltd.	Hamilton, 36 Sun Life Building	Pressed Brick.
Chapman, John	Napanee	Brick and Tile.
Cheeseman, Peter	Hamilton, 670 King St., W.	Brick.
Cooksville Shale Brick Co., Ltd.	Toronto, 26 Queen St., E.	Brick.
Cooper, W. H.	Hamilton, 104 Clyde Block	Brick.
Crang, Jethro	Toronto, 2 Regal Rd.	Brick.
Crawford Bros.	Hamilton, King and Macklin Sts.	Brick.
Curtin, Frank	Lindsay	Brick.
Curtis Bros.	Peterboro, Box 809	Brick and Tile.
Dalton, Maurice	Dresden, R.R. No. 3	Tile.
DeLaplante, J. E., & Co.	Toronto, 1000 Gerrard St., E.	Brick.

BRICK AND TILE PLANTS, 1921—*Continued.*

Name	Address.	Product.
Deller, Albert E	Vienna	Brick, Tile and Blocks.
Deller Bros.	Norwich, R.R. No. 2	Brick, Tile and Hollow Blocks.
Deller, Wm. H	Thorndale, R.R. No. 4	Tile.
Dolan, John	Watford, R.R. No. 2	Tile.
Dominion Sewer Pipe and Clay Industries, Limited	Aldershot and Swansea	Brick, Blocks and Tile.
Don Valley Brick Works	Toronto, 714 Dominion Bank Building	Common, Pressed and Tapestry Brick, Blocks.
Donaldson, S. E.	Harriston, R.R. No. 4	Tile.
Dublin Brick and Tile Company	Dublin	Brick and Tile.
Elliott, Charles	Bluevale	Brick and Tile.
Elliott, Wm.	Glenannan	Brick and Tile.
Elliott, Jas., Jr.	Sault Ste. Marie, 519 Wellington St., N.	Common and Rug Brick.
Fort William Brick and Tile Company	Ft. William, 509 Victoria Avenue	Brick.
Fox, Geo. J	Dresden	Brick.
Frid Bros.	Hamilton	Brick.
Frid, Geo., Company	Hamilton, Main St., W.	Brick.
Fraser & Leith	Blyth	Brick and Tile.
Gardiner, William	Blenheim	Brick and Tile.
Godfrey & Co., Thos.	Carleton Place	Brick.
Grigg, William	Thedford, R.F.D. 1	Tile.
Hallatt, Wm.	Merlin	Tile.
Hallatt & Son, H.	Comber	Brick, Tile and Blocks.
Halton Brick Co., Ltd	Terra Cotta	Pressed Brick.
Hamilton Pressed Brick Co., Limited	Hamilton, Kensington Ave., S.	Pressed Brick.
Hill, Aaron	Essex	Tile.
Hill, A. W.	Coatsworth, R.R. No. 1	Brick and Tile.
Hill Brick Co	Madoc	Brick.
Hinde Bros	West Toronto	Brick.
Hircock Bros. & Company	Bowmanville	Brick and Tile.
Hitch, Mrs. Susan	Ridgetown	Brick and Tile.
Hitch, Thos.	St. Thomas, Box 254	Brick and Tile.
Holland & Son, William	Ruscomb	Brick and Tile.
Howlett, Fred	Petrolia	Brick and Tile.
Huntsville Brick Co	Huntsville, Box 308	Brick.
Interprovincial Brick Co. of Canada, Ltd., The	Toronto, 30 Toronto St.	Pressed Brick.
Jackson Bros.	Brantford	Brick.
Janes, D. A	Mt. Brydges	Brick and Tile.
Jamieson Lime Co.	Renfrew	Brick and Tile.
Jasperson Brick and Tile Co	Kingsville	Brick, Hollow Blocks and Tile.
Jeffrey, Leon	Zurich, R.R. No. 2	Brick and Tile.
Jervis & Son, John	Dorchester Station	Brick and Tile.
Johnson, Jas., Sr.	Pembroke, R.R. No. 3	Brick.
Kerr, Fred	Crediton	Brick.
Koebel, Joseph Z.	St. Clements	Tile.
Kruse Bros.	Seaforth, R.R. No. 3	Brick and Tile.
Kuhn, Jenry H	Centralia, R.R. No. 2	Tile.
Labey & Son, Geo. A	Foxboro	Tile.
Lindsay, Stephen	Wallaceburg	Tile.
MacKay Bros.	Dutton	Tile.
Martin Estate, David	Thamesville	Tile.
McCormick Bros.	Watford, R.R. No. 5	Brick and Tile.
McGregor & Gammage	Dresden, R.R. No. 2	Tile.
McIvor Bros.	Cobourg, Box 636	Brick.
McLoughlin, Jno.	London, 1044 William St.	Brick.
McMahon, Robert	Kerwood, R.R. No. 2	Tile.

BRICK AND TILE PLANTS, 1921—*Continued.*

Name.	Address	Product
Merkley's, Ltd.	Ottawa, 53 Queen St.	Brick.
Middleton, Chas.	Wyoming	Tile.
Mills, Geo. E.	Hamilton, 614 King St. E.	Brick.
Milton Pressed Brick Co., Ltd.	Milton	Pressed Brick.
Miner, J. T.	Kingsville, R.R. No. 2	Tile.
National Fire Proofing Co. of Canada, Ltd.	Toronto, 601 Dominion Bank Building	Tile and Blocks.
New, Edward	Hamilton, Dundas Rd.	Brick.
Norton, Alsey	Bolton	Tile.
O'Dell, Albert & Henry	Ingersoll	Brick, Tile and Blocks
Ontario Brick and Tile Plant	Mimico	Brick, Tile and Blocks.
Ontario Paving Brick Co., Limited	West Toronto	Brick.
Ollman Bros	Hamilton, Macklin St.	Brick.
O'Reilly, T. E.	Ottawa, 320 Bay St.	Brick.
Ott Brick and Tile Mfg. Co., Ltd., The	Kitchener	Brick, Tile and Blocks.
Ottawa Brick Mfg. Co., Limited, The	Ottawa, 53 Queen St.	Brick.
Owen Sound Brick Co., Limited, The	Owen Sound	Brick.
Paxton & Bray	St. Catharines, Queenston Street	Brick.
Pears & Son, James	Toronto, Eglinton Ave., W.	Brick.
Pembroke Brick Co., The	Pembroke	Brick.
Phillips & Son, Thos	Lucknow, R.R. No. 2	Tile.
Phippen & Field	Toronto, Dawes Road	Brick.
Phinn Bros	London, St. James Park	Brick and Tile.
Piggott & Co., Geo.	Mount Dennis, 20 Guestville Ave	Brick.
Port Credit Brick Co., Limited, The	Port Credit	Pressed Brick.
Price & Cumming	Humber Bay, Salisbury Avenue	Brick.
Price & Smith	Toronto, 458 Greenwood Avenue	Brick.
Price, Ltd., Jno	Toronto, 395 Greenwood Avenue	Brick.
Richardson & Son, James	Kerwood	Brick and Tile.
Rollins, D. W.	Belleville, R.R. No. 4	Brick.
Shale Products, Ltd	Inglewood	Brick.
Snelgrove, A	Beaverton	Brick and Tile.
Sproat, Wm. M.	Seaforth, R.R. No. 4	Brick and Tile.
Standard Brick Co., Ltd	Toronto, 363 Broadview Avenue	Brick.
Stroh, M. C.	Conestogo	Brick and Tile.
Superior Tile Co., Limited	Fort William	Common and Tapestry Brick.
Telford, John C	Southwold	Tile.
Tilbury Brick and Tile Co., Ltd., The	Tilbury	Brick, Tile and Blocks.
Tolson, Mrs. Margaret J.	Highgate. R.R. No. 1	Brick and Tile.
Tope Estate, Richard	Hamilton, 171 Queen St., S	Brick.
Toronto Brick Co	Toronto, 60 Victoria St.	Brick.
Turner & Co., C. B	Toronto, 894 Bathurst St.	Brick.
Wagstaff & Co., A. H.	Toronto, 348 Greenwood Avenue	Brick.
Wagstaff, Charles	Lindsay, R.R. No. 4	Tile.
Waide, J. C.	London, 1010 Adelaide St.	Brick.
Waite, John E.	Forrester Falls	Brick and Tile.
Wallace & Son, R	North Bay	Brick.
Warwick Brick Works	London, 647 Grosvenor St.	Brick.
Whitby Brick and Clay Products Co., Ltd.	Whitby, Box 96	Brick.
Wilson, Samuel & Sons	Paisley, R.R. No. 2	Brick and Tile.
Winch Bros	Paisley, Box 220	Brick and Tile.
Windsor Brick and Tile Co	Windsor, 201 Exchange Building	Brick, Tile and Blocks.
Woodslee Brick and Tile Co	Woodslee	Brick and Tile.
Wright & Sons, Geo	Comber, Box 56	Tile.
Wright, J. C.	Proton	Brick and Tile.

Portland Cement

The capacity of the plants operated during the year was 12,500 barrels per day. An average of 883 men were employed, and wages amounted to $1,228,460.

Following is a list of the operating plants:—

PORTLAND CEMENT PLANTS OPERATING IN 1921.

Company.	Location of Plant.	Head Office Address.
Canada Cement Company, Ltd.		Herald Bldg., Montreal, Quebec.
Plant No. 4	Thurlow tp.	
Plant No. 5	Thurlow tp., near Belleville	
Plant No. 8	Port Colborne	
Hanover Portland Cement Co., Ltd., The.	Hanover	Hanover.
St. Marys Cement Co., Limited	St. Marys	St. Marys.

The following table gives details of the industry in 1913, during the war period and subsequently:—

PORTLAND CEMENT STATISTICS, 1913-1921.

Year	No. of Operating Plants.	Stock on hand Dec. 31st bbls.	Sales.		Average Price per bbl. (350 lbs.)
			Barrels.	Value	
				$	$
1913	13	450,213	3,802,321	4,105,455	1.08
1914	11	846,562	2,665,650	2,931,190	1.10
1915	7	755,799	2,302,242	2,534,537	1.10
1916	7	380,458	2,143,949	2,242,433	1.05
1917	6	567,261	2,063,231	2,934,271	1.42
1918	4	473,184	1,226,244	1,910,839	1.56
1919	5	278,188	2,022,575	3,659,720	1.81
1920	5	248,142	2,035,594	4,377,814	2.15
1921	5	174,686	2,723,072	6,425,266	2.37

In the United States the factory price per barrel of 380 pounds ranged from $1.73 in the East to $2.58 in the West, the average price being $1.89 per barrel.

Concrete Products.—The term "concrete" as usually understood refers to a compact mass of sand and gravel or crushed stone bound together by Portland cement. Monolithic concrete construction is not considered in this report, which deals only with moveable concrete products. In the United States approximately one barrel of cement is used to one ton of aggregate. As the materials entering into concrete receive individual consideration, the statistics of production of concrete products are not included in the summary of mineral output of the Province (Table I).

In 1921, there was an output of 441,243 concrete brick, 801,748 drain pipe. and 151,247 sewer pipe and culvert tile. For the most part the industry is not carried on during the winter months. Detailed statistics for the past five years follow:

CONCRETE PRODUCTS STATISTICS, 1917-1921.

Schedule	1917	1918	1919	1920	1921
Brick . . . . $	1,420	1,290	10,631	11,117	9,235
Blocks, sills and caps . . . . $	8,312	41,362	147,895	382,994	409,722
Drain tile . . . . $	90,586	81,351	142,072	338,286	70,412
Sewer pipe and culvert tile . . . . $					317,811
Artificial stone and other products . . $	. . . .	. . . .	. . . .	. . . . . .	87,701
Total value of output . . . . $	100,318	124,003	300,598	732,397	894,881
Average period of operation . . . . days	105	122	108	161	224
Employees . . . . No.	105	72	148	218	230
Wages . . . . $	28,641	25,901	90,653	212,014	253,141

PRODUCERS OF CONCRETE PRODUCTS, 1921.

Producer.	Location.	Kind of Product Made.
Andrews, S. J	Clinton	Building Blocks, Drain Pipe, Sewer Pipe and Culvert Tile.
Anthistle, W. J	London	Vaults.
Arthur, Corp. of Township of . .	Kenilworth . . .	Sewer Pipe and Culvert Tile.
Ashman, T. J	London	Building, Blocks, Heads and Sills.
Banks, John	London	Building Blocks, Artificial Stone.
Bawden, F. W	Exeter . . .	Building Blocks, Drain Pipe, Posts.
Beuglas, Jas	Bright	Sewer Pipe and Culvert Tile.
Bowers, E. G	Cottam	Building Blocks, Drain Pipe, Culvert Tile, Sewer Pipe.
Bishop, Thos. Wm	Ridgeville	Cement Bricks, Building Blocks, Drain Pipe, Sewer Pipe and Culvert Tiles, Artificial Stone, Caps, Posts.
Brigden, Henry	Bruce	Building Blocks.
Brown, D. L	Sudbury .	Cement Bricks, Building Blocks.
Burkholder, George . .	Whitevale .	Drain Pipe.
Calder, James	Fergus .	Sewer Pipe and Culvert Tile.
Corinthian Stone Co	Guelph .	Artificial Stone.
Cross Builders Supply Co., Ltd	Windsor	Building Blocks.
Concrete Pipe and Products Co	Hamilton	Building Blocks, Drain Pipe, Sewer Pipe, Culvert Tile, Septic Tanks, Artificial Stone.
Canadian Concrete Products Co	Chatham	Sewer Pipe and Culvert Tile, Pipe Carrier Foundations, Battery Wells, Battery Boxes.
Cast Stone Block and Machine Co . . .	Windsor	Cement Bricks, Building Blocks, Machinery Sales, Cement, Granite and Gravel Sales.
Chatham Cement Tile and Block Co .	Chatham	Building Blocks, Drain Pipe.
Christie Concrete Products	Lindsay	Cement Bricks, Building Blocks, Drain Pipe, Sewer Pipe, Culvert Tile, Artificial Stone.
Clarkson Cement Tile and Brick Co . .	Toronto	Cement Bricks, Building Blocks, Drain Pipe, Sewer Pipe and Culvert Tile, Artificial Stone.
Dewitt, W. J	Locust Hill .	Sewer Pipe and Culvert Tile.
Deline, L	Enterprise	Building Blocks, Sewer Pipe and Culvert Tile.
Doidge, James A	Hamilton	Building Blocks, Drain Pipe.
Elridge, George	Sarnia	Building Blocks.
Elliott, J. A	Dunsford . . .	Building Blocks.
Fletcher & Son, J. H . .	Ridgeville	Building Blocks, Cistern Block.
Flowers, Wm. T	Caledonia . . .	Building Blocks, Sewer Pipes and Culvert Tile.

PRODUCERS OF CONCRETE PRODUCTS, 1921—*Continued.*

Producer.	Location	Kind of Product Made.
Fulton, John	Pakenham	Sewer Pipe and Culvert Tile.
Garnet & Sons, Thos.	Port Hope	Cement Bricks, Building Blocks, Sewer Pipe and Culvert Tile.
Gillis, Alfred	Galt	Cement Bricks, Building Blocks, Artificial Stone, Lawn Vases and Laundry Tubs.
Granite Concrete Block Co.	Toronto	Building Blocks, Lintels.
Hall & Tampling	Dunnville	Building Blocks.
Hare, John	Markham	Building Blocks, Sewer Pipe and Culvert Tile.
Hewitt & Son, A. B.	Princeton	Building Blocks, Drain Pipe.
Hunt & Sons, J. W.	Mount Forest	Drain Pipe, Sewer Pipe and Culvert Tile.
Hyndman, Jno	Gorrie	Drain Pipe, Sewer Pipe and Culvert Tile.
Independent Concrete Pipe Co.	Woodstock	Drain Pipe, Sewer Pipe and Culvert Tile.
Ingrouille, Stephen	Strathroy	Sidewalks, Outside Coffin Boxes.
Jacques, Ulderic	Windsor	Building Blocks.
Kilbourne & Son, H.	London	Building Blocks, Artificial Stone.
Kingston Cement Products—Horace F. Norman	Kingston	Building Blocks, Artificial Stone, Grave Vaults, Ornaments.
Kinzel Bros	Preston	Building Blocks.
Lefebvre, Jos.	Windsor	Building Blocks.
Lesperence, Peter J.	Ford	Cement Bricks.
Lishman, W. H.	Cayuga	Cement Bricks, Building Blocks, Sewer Pipe and Culvert Tile.
McQueen, Alex	Moorefield	Cement Bricks, Drain Pipe, Sewer Pipe and Culvert Tile.
McLenaghan, W. A.	Essex	Building Blocks.
Marty, Emil	St. Catharines	Building Blocks.
Mitchell, Ralph R.	Niagara Falls	Building Blocks.
Miller, Thos.	Sandwich	Building Blocks.
Morse, W. O.	Campbellville	Sewer Pipe and Culvert Tile.
Ord, John A.	Guelph	Drain Pipe.
Oakes, Sam	Burlington	Cement Bricks, Building Blocks.
Oil Springs Tile and Cement Co.	Oil Springs	Cement Window Sills, Building Blocks, Drain Pipe.
Page, George Leslie	Lucknow	Drain Pipe.
Palm, Jacob	Mildmay	Sewer Pipe and Culvert Tile.
Peerless Artificial Stone Co.	Toronto	Artificial Stone, Laundry Tubs.
Pfaff, Wm. E.	Hensall	Cement Bricks, Building Blocks, Drain Pipe, Sewer Pipe and Culvert Tile, Verandah Posts and Caps.
Reid, M. P.	Kingston	Cement Bricks, Building Blocks.
Robidoux, H. L.	Amherstburg	Cement Bricks, Building Blocks, Drain Pipe, Sewer Pipe and Culvert Tile, Artificial Stone.
Robinson, Ed	Mitchell	Drain Pipe, Sewer Pipe and Culvert Tile.
Ross & Son, Chas.	Dunnville	Sewer Pipe and Culvert Tile.
Russelo, Howard	Leamington	Building Blocks, Sewer Pipe and Culvert Tile.
St. Onge, Hormidas	Windsor	Building Blocks.
Schmidt, J. T.	Waterloo	Cement Bricks, Drain Pipe, Sewer Pipe and Culvert Tile.
Schram, A. J.	Camlachie	Drain Pipe.
Shoemaker, Allen	Kitchener	Drain Pipe.
Showel Bros	Owen Sound	Sewer Pipe and Culvert Tile.
Smith, Albert	West Lorne	Cement Bricks, Building Blocks.
Smith, Allan G. C.	Acton	Building Blocks, Sewer Pipe and Culvert Tile, Sills and Lintels.
Smithson, Frank	Leamington	Sewer Pipe and Culvert Tiles.

PRODUCERS OF CONCRETE PRODUCTS, 1921—*Continued.*

Producer.	Location	Kind of Product Made
Somerville & Son, W. G.	Welland	Building Blocks, Sewer Pipe and Culvert Tile.
Stanley, J.	Stanley Corners	Cement Bricks, Building Blocks, Sewer Pipe and Culvert Tile, Sills, Chimney Base and Crown.
Stinson, R. H.	Omemee	Sewer Pipe and Culvert Tile.
Sydenham Block and Tile Co.	Wallaceburg	Building Blocks.
Taylor & Hall	Peterboro	Building Blocks, Sewer Pipe and Culvert Tile.
Telford, Peter	Holland Centre	Drain Pipe, Sewer Pipe and Culvert Tile, Well Blocks, Troughs and Reducers.
Theaker, Wm.	Bartonville	Building Blocks, Window Sills, Lintels.
Tigert, Jno.	Port Albert	Drain Pipe, Sewer Pipe and Culvert Tile.
Watts, Alfred	Tillsonburg	Building Blocks, Sewer Pipe and Culvert Tile, Window Sills and Pier Caps.
White, Sidney	St. Catharines	Building Blocks.
Whitlock, Peter	Hensall	Building Blocks, Sewer Pipe and Culvert Tile.
Williams, E. J.	Wheatley	Building Blocks, Drain Pipe, Sewer Pipe and Culvert Tile, Artificial Stone, Flower Pots, Sidewalks.
Winchester Cement Block and Tile Mfg. Co.	Winchester	Drain Pipes.
Young & Son, John	Ridgeway	Building Blocks, Sewer Pipe and Culvert Tile.

Lime

The day of small lime-kilns perched on a hillside or nestling on the river bank has passed. They have given way to modern plants capable of producing more and better lime. Following the introduction of Portland cement nearly a century ago, lime was gradually displaced to some extent for construction work. In recent years investigation has proved that hydrated lime mixed with cement mortar or concrete mixtures produces beneficial effects. It improves the workability, facilitates passing concrete through chutes, and increases the density and water-tightness. The strength of cement mortar is increased when quantities up to 10 per cent. by weight of hydrated lime are added to or substituted for Portland cement. On the other hand where great loads are carried and where work is conducted under freezing conditions cement in lime mortar has distinct advantages.

Statistics of lime marketed or used during the past five years are given in the following table:

LIME STATISTICS, 1917-1921.

Year.	Lime Marketed.						Fuel Cost $	Employees.	Wages $
	Hydrated.			Total Lime. (Hydrated and Quicklime.)					
	Tons.	Total Value. $	Per Ton. $	Bush.	Value. $	Ave. Price per bush. c.			
1917	......	....	......	2,820,507	657,364	23.3	....	325	262,132
1918	......	....	......	2,650,285	872,177	32.9	237,425	287	300,746
1919	30,454	307,342	10.09	3,991,572	1,268,290	32.4	302,144	363	366,686
1920	28,591	397,305	13.89	4,982,912	1,799,763	36.2	546,604	448	568,513
1921	26,863	381,749	14.58	3,530,547	1,344,188	38.0	....	366	341,826

Below are given the names of producers and the location of plants operated in 1921:—

LIME PRODUCERS, 1921.

Name of Owner or Company.	Location of Kilns.	Head Office Address.
Alabastine Co., Paris, The (*)	Elora	Paris.
American Cyanamid Co	Niagara Falls	Niagara Falls.
Beachville White Lime Co., Ltd	Beachville	Beachville.
Bergin, Patrick	Napanee	Napanee.
Brunner Mond Canada, Limited	Anderdon tp., near Amherstburg	Toronto, Bank of Commerce Building.
Biederman, A. G.	Golden Lake	Golden Lake, R.R. No. 1.
Canada Lime Co.	Coboconk	Lindsay.
Chalmers Lime Works	Owen Sound	Owen Sound.
Christie, Henderson & Co., Limited (*)	Hespeler, Galt, Puslinch, Kelso	Toronto, 201 Crown Office Building
Dominion Sugar Company	Chatham, Wallaceburg and Kitchener	Chatham.
Flieler, Edward	Clarendon	Fernleigh.
Gallagher Lime and Stone Co., Limited	Barton tp.	Hamilton.
Harvey, E., Limited	Rockwood	Guelph.
Jamieson Lime Co.	Renfrew	Renfrew.
Jamieson, J. M.	Ross tp.	Forrester Falls.
Marshall, James	Barton tp.	Hamilton.
O'Donohue, Michael	Campbellford	Campbellford.
Parks Bros.	Beverley tp.	Troy.
Robertson Co., Limited, D.	Nassagaweya tp.	Toronto, 26 Queen St., E.
Smith, John S.	Kincardine	Kincardine.
Standard White Lime Co., Limited (*)	Beachville, Guelph	Guelph.
Toronto Brick Co., Limited	Coboconk	Toronto, 60 Victoria St.
Toronto Lime Co., Limited	Dolly Varden	Toronto, 26 Queen St., E.
Toronto Plaster Co., Limited, The (*)	Teeswater	Teeswater.
Vogan, Samuel	Wiarton	Wiarton.
Weppler, Henry	Glenelg tp.	Priceville, R.R. No. 2.

---

*Producers of hydrated lime.

Sand-Lime Brick

Brick are made from sand and lime by compressing these materials in moulds and subjecting the resulting product to a steam bath. These brick will not stand rough handling before they are well cured. They find a ready market, particularly as inside brick, the cost being less than for the clay product.

Seven plants operated in 1921, the output being 36,482 M. worth $534,531, or an average of $14.64 per M. The industry gave employment to 131 men, whose wages totalled $141,460. Production in 1920 was 27,703 M., worth $407,766, or an average of $14.72 per thousand.

The following plants were operated during the year:—

SAND-LIME BRICK PRODUCERS, 1921.

Name.	Location of Plant.	Address.
Caledon Brick Co., Ltd.	Caledon E.	171 Yonge St., Toronto.
Canada Sand-Lime Pressed Brick Co., Ltd.	West Toronto	28 Symes Rd., Toronto
Toronto Brick Co., Limited	Scarboro and Swansea	60 Victoria St., Toronto.
West Lake Brick and Products Co.	West Lake	R.R. No. 1, Picton.
Willcox Lake Brick Co., Ltd.	Whitchurch tp.	Richmond Hill.
York Sandstone Brick Co., Ltd.	Gerrard St. and Victoria Avenue	E. Toronto.

Sand and Gravel

Out of a total of 6,273,173 tons of sand and gravel reported, 2,943,959 tons was used for railway ballast: glass sand consumption was 135 tons: moulding sand 90,901; blast and engine sand 6,746 tons.

Following is a list of sand and gravel pit operators who marketed or used 1,000 cubic yards or more during the year:—

SAND AND GRAVEL OPERATORS, 1921.

Name of Owner or Company.	Material G = Gravel S = Sand	Location of Deposits	Address.
Aldborough, Township of	G.	Aldborough tp., lot A, con. 7	Rodney.
Allan Bros.	S. and G.	Stop 19, Kingston Rd.	Toronto, 60 Birchcliffe Ave.
Allan, Mrs. M.	S.	Grantham tp., lot 7, con. 2	St. Catharines, R.R. No. 4.
Armstrong Supply Co., Ltd., The	S.	1143 York St., Hamilton	Hamilton, 34 James St., N.
Ashton & Sons, E.	S.	Scarborough tp., Victoria Park, W.	Toronto, 1354 Queen St., E.
Bellyou, Norman E.	S. and G.	Murray tp., lot 6, con. 1	Trenton, R.R. No. 4.
Bennett, Joseph	S.	Scarlett Rd., York tp.	Toronto, 145 Caledonia Rd.
Benson & Patterson	S. and G.	Stamford tp., lot 17-18	Stamford.

SAND AND GRAVEL OPERATORS, 1921—*Continued*

Name of Owner or Company	Material G=Gravel S=Sand	Location of Deposits	Address.
Blair & Son, James	S.	Fitzroy tp., lot 22, con. 4	Arnprior.
Boyd Bros	G.	Osgoode tp., lot 27, con. 4	Osgoode.
Brantford, Corporation of City of	S. and G.	Brantford tp	Brantford, City Hall.
Brown & Sons, Wm	S. and G.	Smith tp., lot 19, con. 3 and lot 18, con 2.	Peterborough, Box 784.
Campbellford, Town of	S. and G.	Seymour tp., lot 5	Campbellford.
Carroll Bros	S.	Humberstone tp., lots 3, 4, 5, 6, 7, 8, 9, con. 1	Buffalo, N.Y., 490 Ellicott Square.
Cleary, Thomas	S. and G.	Cornwall tp	Mille-Roches, Ont.
Conlon, John J	S.	Pelham tp., lot 4, con. 8	St. Catharines, 31 Maple St.
Construction and Paving Co. of Ontario, Ltd	S. and G.	Erin tp	Toronto, 708 Confederation Life Bldg.
Cotterill, Alfred A	S.	Westminster tp	London, 81 Briscoe St.
Crosthwaite, F	S.	Barton tp., lot 3, con. 3	Bartonville, Ont.
Cudmore, J. W	G.	Howard tp., lot 12, con. 1	Thamesville.
Dean, Harry F	G.	Middleton tp., con. 2.	Tillsonburg, R.R. No. 2.
Dereham, Tp. of	S. and G.	Dereham tp., lot 16, con. 10	Mount Elgin.
Donald, Andrew	G.	Dereham, lot 22, con. 7	Ingersoll, R.R. No. 1.
Donaldson, W. J	S. and G.	Fitzroy tp., lot 27, con. 3.	Arnprior.
Doyle, Wm	S. and G.	Oneida tp., lot 16, con. 4	Caledonia, R.R. No. 3.
Elgin, County Highways	S. and G.	Yarmouth tp., lot 3 con. 4; Aldborough tp., lot C, con. 7; Southwold tp., lot 13, con. 5	St. Thomas, Court House
Empire Limestone Co	S.	Sherkston	Buffalo, N.Y., 19 Hudson St.
Faulds, Morley	S. and G.	Southwold tp., lots 12 and 14, con. 5	Iona Station, R.R. No. 4.
Fonthill Gravel Co., Ltd	S.	Fonthill	Thorold.
Forbear Sand and Gravel Co	S.	Vaughan tp., lot 22, con. 3	Maple.
Foster, R.R	S. and G.	Ottawa, Gloucester tp.	Ottawa, 278 Echo Drive.
Frid Bros	S. and G.	Hamilton, Dundas Rd. and Macklin St	Hamilton, Dundas Rd. and Macklin St.
Godson Contracting Co., Ltd	S. and G.	Brock tp., lot 12, con. 4	Toronto, 113 Manning Chambers.
Guelph, City of	G.	Guelph	Guelph, City Hall.
Hamilton Sand and Gravel, Ltd	S. and G.	Burlington Heights	Hamilton, 110 Queen St., N.
Harwich Township	S. and G.	Harwich tp	Blenheim.
Hoffman, Jas	S. and G.	City of Kitchener	Kitchener, 27 Pine St.
Hydro-Electric Power Commission	S.	Stamford tp	Toronto, 187 University Ave.
Iroquois Sand and Gravel Co., Ltd	S. and G.	Scarborough tp., lot 9, con. 2	Toronto, 1107 Royal Bank Bldg.
Kent, County of	S.	Raleigh tp	Chatham.
Kilbourne & Son, Harvey	S.	Westminster tp., Wharncliffe Rd	London, 9 Cove Road.
Kingston Sand and Gravel Co	S.	Kingston tp., lots 33-34, con. 5	Kingston, 179 Stuart St.

SAND AND GRAVEL OPERATORS, 1921—*Continued*

Name of Owner or Company	Material G=Gravel S=Sand	Location of Deposits	Address
Larter, Chas	S. and G.	North Dumfries tp.	Galt, 76 Chalmers St.
Lambton, County of	S.	Enniskillen tp., lot 9, con. 13	Sarnia.
Lane, George	G.	Thurlow tp., con. 2	Belleville.
Le Viness & Sons, A.	S.	Stamford tp., lot 37	Stamford.
Lyons Fuel and Supply Co	G.	Mile 34, A.C.Ry.	Sault Ste. Marie, Ont.
Malahide tp.	G.	Malahide tp., lot 21, con. 6	Aylmer.
Malloy, Wm. B.	S. and G.	Ellice tp., lot 8, con. 4	Sebringville, R.R. No. 1.
Maple Sand, Gravel and Brick Co.	S. and G.	Vaughan tp., lots 21-24 con. 3	Toronto, 454 King St., W
McAlpine, Daniel	G.	Dunwich tp., lot 10, con. A	Dutton.
Middlesex, County of	S. and G.	Numerous places	London, County Bldgs.
Millard, David	S.	Whitchurch tp., lot 33, con. 3	Newmarket.
Mills, James	S. and G.	Downie tp., lot 12, con. 5	Stratford, R.R. No. 3.
Moyer, Lovelace Co., Ltd	S.	Pelham tp., lots 6 and 7, cons. 8 and 9	St. Catharines.
Oakland Sand and Gravel Co	S. and G.	Oakland tp., con. 3	Niagara Falls.
Ollman Bros	S.	Hamilton, Macklin St.	Hamilton, Macklin St.
Ontario Highways Dept	S. and G.	Numerous pits	Parliament Bldgs., Toronto.
Paris Sand and Gravel Co	S. and G.	S. Dumfries tp., lot 34, con. 1	Paris, R.R. No. 2.
Peterborough, City of	S. and G.	Hilliard farm, block G., south of north city limit	Peterborough, 133 Simcoe St.
Ponsford, A. E.	S. and G.	Yarmouth tp., lot 1, con. 7	St. Thomas, 605 Talbot St.
Porter, Thompson	S.	York tp., lots 28 and 29	Mt. Dennis, 866 Weston Road.
Prior, Elston M.	G.	Yarmouth tp., lot 16, con. 4	St. Thomas, R.R. No. 4
Quick, Chas. R.	S. and G.	Westminster, Manor Park	London, 101 Briscoe St.
Quigley, B. C.	S. and G.	Saltfleet tp., lot 29, con. 3	Hamilton.
Redden, Henry	S. and G.	Campbellford, Kent St	Campbellford.
Rideau Canal Supply Co., Ltd	S.	Hogs Back, Gloucester tp.	Ottawa, Rideau Canal Basin.
Sand and Supplies, Ltd	S. and G.	Waterloo Co., near Ayr	Toronto, 54 University Ave.
Sarjeant Co., The	S. and G.	Barrie, James and Penetang Streets	Barrie, Dunlop St.
Shannon, Hiram L.	S. and G.	Richmond tp., lot 6, con. 3	Napanee, R.M.D. No. 5.
Shirk, Geo. M.	S. and G.	Bridgeport	Bridgeport.
Skinner, Robt	G.	Usborne tp., lot 11, con. 5.	Exeter.
Sleeman, P	S. and G.	Hope tp., lot 9, con. 2.	Port Hope.
Smith Estate (F. S. Scott)	S. and G.	N. Dumfries tp., lot 8, con. 12	Galt.
Stothart, James	S.	Smith tp., lot 17, con. 2	Peterborough, R.R. No. 4.
Sulley, W. J	S.	Darlington tp., lot 28, con. 4	Courtice.

SAND AND GRAVEL OPERATORS, 1921—*Continued*

Name of Owner or Company	Material G=Gravel S=Sand	Location of Deposits	Address
Tarentorus, Township of	S. and G.	Tarentorus tp., sec. 29	Sault Ste. Marie.
White & Co., Homer	G.	Hallowell tp., lot 22	Picton.
Willox, Henry	S.	Stamford tp., part lots 4 and 17	Niagara Falls, 209 Bridge St.
Windsor, Essex and Lake Shore Ry., Co.	G.	Mersea tp., W. of Leamington	Kingsville.
Windsor Sand and Gravel Co., Ltd., The	S. and G.	Two miles west of Leamington	Windsor, 57 Hall Ave.
Wright & Co.	S.	Korah tp., sec. 13	Sault Ste. Marie, 960 Queen St.
Yack, Henry	S.	London tp., lot 12, con. 2	London.
Yarmouth, Township of	S.	Yarmouth tp., lot 8, con. 5	St. Thomas, Southern Loan Chambers.

The Department of Mines issues licenses and collects a royalty on the removal of sand and gravel from the beds of the great lakes and rivers. The revenue from this source accruing to the Ontario Government was $112,996.95 for the calendar year of 1921, and the quantity of sand and gravel removed was 599,655 cubic yards. Following is a list of such licensees:

SAND AND GRAVEL LICENSEES, 1921.

Name of Company	Material. G=Gravel S=Sand	Location of Deposit	Address
Abitibi Power and Paper Co	S. and G.	Township of Rickard	Iroquois Falls.
Cadwell Dredging Co., Ltd	G.	St. Clair River	Windsor.
Chatham Sand and Gravel Co	S. and G.	Thames River	Chatham.
Chick Contracting Co	G.	St. Clair River	Windsor.
Cameron Steamship Co	G.	St. Clair River	Detroit, 39 Buhl Bldg.
Department of Railways and Canals	G.	Niagara River	Ottawa.
Great Lakes Transportation Co	S.	Thunder Bay	Fort William.
Gleason, F. D., Coal Co	S. and G.	St. Clair River	Detroit, Mich., 28 Campau Building.
Hadley Co., Ltd., The C. & J.	S. and G.	Thames River	Chatham.
Homegardner Sand Co	S.	Dummy Foundation, Lake Erie	Sandusky, Ohio.
International Sand and Gravel Co.	G.	St. Clair River	Detroit, 47 Campau Bldg.
Kelley Island Lime and Transport Co.	S. and G.	Lake Erie	Sandusky, Ohio.
Lake Erie Sand Co.	S.	Dummy Foundation, Lake Erie	Sandusky, Ohio.
Marysville Land Co	G.	St. Clair River	Marysville, Mich.
National Sand and Material Co	S. and G.	Lake Erie	Welland.
Niagara Sand Corp. (J. E. Carroll and T. E. Milburn)	S. and G.	Niagara River	Buffalo, N.Y., 915 White Building.
Superior Sand and Gravel Co	S. and G.	St. Clair River	Detroit, Mich.
United Fuel and Supply Co	G.	St. Clair River	Detroit, Free Press Bldg.

Stone

As noted in Table I the total output of stone of all grades was 2,716,080 tons valued at $4,167,582. The tonnage of sandstone was 3,267: trap 152,899; and granite 6,153. Of the limestone sold or used over 90 per cent. was in the form of crushed stone, mainly for concrete and road purposes.

The table which follows shows the valuation of the several kinds of stone marketed or used over a five-year period:

VALUE OF STONE PRODUCTION, 1917-1921.

Year	Limestone	Sandstone	Trap	Granite	Marble	Total
	$	$	$	$	$	$
1917	728,975	115,932	70,570	25,575	....	941,052
1918	820,985	145	24,744	23,334	....	869,238
1919	1,112,340	5,544	82,995	10,683	19,360	1,230,922
1920	3,786,263	10,502	92,630	55,277	300	3,944,972
1921	3,934,045	6,423	158,467	68,647	.....	4,167,582

STONE QUARRY OPERATORS, 1921.

Name of Owner, Firm or Company	Location	Kind of Stone
Abitibi Power and Paper Co	Farr quarry, Bucke tp	Limestone.
Abrams, J. M	Gananoque	Granite.
Alabastine Co., Paris, Ltd	Nichol tp	Limestone.
Ball, B. W	Woodhouse tp	Limestone.
Bergin, Patrick	Napanee	Limestone.
Bolender Bros	Haliburton	Crystalline Limestone.
Britnell & Co., Ltd	Somerville tp	Limestone.
Brown, A. C	Leeds tp	Monumental Granite.
Brantford and Hamilton Electric Railway Co., Ltd	Ancaster	Limestone.
Bruce Mines Trap Rock Co., Limited	Bruce Mines	Trap.
Brunner, Mond Canada, Ltd	Amherstburg	Limestone.
Caldwell Bros	Gloucester	Limestone.
Campbell and Lattimore	Findley	Granite.
Carleton County (W. J. Farmer and Caldwell Bros)	Osgoode and Gloucester tps	Limestone.
Canada Crushed Stone Corporation, Ltd	Dundas	Limestone.
Cayuga Stone Co	Nelles	Limestone.
Cook, J. S., & Son	Wiarton	Limestone.
Crushed Stone, Limited	Eldon	Crushed Limestone.
Dept. of Prov. Secty., Ont. Prisons and Asylums Branch	Guelph tp	Limestone.
Department of Public Highways	Toronto	Limestone and Dolomite.
Fort William, Corp. of the City	Rifle Range, Ft. William	Trap Rock.
Foster & Cram	Merevale Rd., City View Ottawa	Limestone.
Gallagher Lime and Stone Co	Hamilton	Limestone.
Gosselin, Chas	Quarries, Russell Co	Limestone.
Gow, James	Fergus	Limestone, Dolomite.
Hagersville Crushed Stone Co., Ltd	Hagersville	Limestone.
Hagersville Quarries	Walpole tp	Limestone.
Haldimand County Good Roads System	Nelles and Dunnville	Limestone.

STONE QUARRY OPERATORS, 1921—*Continued*

Name of Owner, Firm or Company	Location	Kind of Stone
Hamilton, Corporation of	Hamilton	Limestone.
Henderson Farmers' Lime, Ltd	Woodstock	Limestone.
Higginson, Geo., & Son	Coldwater	Limestone.
Hildreth, Chas	Barton, lot 6, con. 12	Limestone.
Horne, Wm	Butler	Granite.
Hydro-Electric Power Commission	Brant tp	Limestone.
Kingston Penitentiary Quarries	Portsmouth	Limestone.
Lally, E	Smithville	Limestone.
Law Construction Co., The	Bertie tp	Limestone.
Lincoln County	N. Grimsby tp	Limestone.
Longford Quarry Co., Limited	Longford Mills	Limestone and Riprap.
McNeely, D. R	Beckwith tp	Limestone.
Markus, Wm., Ltd	Pembroke	Limestone.
Middleton, John N	Ancaster	Limestone.
McDonnell, George	Wolfe Island tp	Limestone.
Mond Nickel Co., Ltd	Drury and Levack tps	Trap Rock.
Mills, Jas	Napanee	Limestone.
Morrison Bros	Cochill	Granite.
Muskoka Quarries, Ltd	Draper tp	Granite
Ontario Rock Co., Ltd	Belmont and Methuen tps	Trap Rock.
Ontario Stone Corporation, Limited	North Orillia tp	Limestone.
Ottawa Improvement Commission	Corner Bell and Carling, Ottawa	Crushed Stone.
Owen Sound, Board of Works	Owen Sound	Limestone.
Pearce Company, Ltd	Marmora	Limestone.
Perkins, Geo. A	Owen Sound	Limestone.
Point Anne Quarries, Limited	Point Anne	Limestone.
Reid, C. F	Odessa	Sandstone.
Rideau Canal Supply Co., Limited	Ottawa	Limestone.
Robertson, D., & Company, Limited	Milton	Sandstone.
Robillard, H., & Son	Ottawa	Limestone.
Roddy & Monk	Kingston	Limestone.
Rogers, F., & Co	Chinguacousy tp	Sandstone.
Standard White Lime Co., Limited	Beachville	Limestone.
Streets and O'Brien	Leeds tp	Granite.
Thames Quarry Co	St. Marys	Limestone.
Walker Bros	Thorold	Limestone.
Wallace, R., & Sons	Stephen St., Kingston	Limestone.
Webber, John	Dunn tp	Limestone.
Webster, Jas. S	Foot of Augusta St., Galt	Limestone.
Wentworth Quarry Company, Ltd	Saltfleet tp	Limestone.
Wilson, Geo. S	Perth, R.R. No. 3	Sandstone.

Mining Divisions

Following is a summary of the comments by Mining Recorders on the subject of mining and prospecting activity in their respective Divisions:

Sudbury—A little more prospecting activity than usual has been manifested in the neighbourhood of Lake Wanapitei.

Porcupine—Promising gold finds are reported in Ogden, Bristol and Cody townships. Favourable results from diamond-drilling have been obtained at the Night Hawk Peninsular mine. The Dome, Hollinger and McIntyre mines are working to capacity and mill additions under construction at the last mentioned will considerably increase the production. The power situation is causing uneasiness in the camp, but hydro-electric developments are under way at Sturgeon Falls and Indian Chutes, that should improve conditions before next winter.

Larder Lake—There was activity in all parts of this Division during the year 1921. In McVittie, Gauthier, Lebel and Teck townships, particularly, a large number of claims have been staked with good gold values, resulting in several groups of claims being purchased by well-known mining companies from Porcupine and Cobalt. From reports, there are at present a great many prospectors scattered throughout the whole of this Division, and it would appear that in at least 75 per cent. of the townships good gold values have been obtained. Every indication points to 1922 being a very busy year.

Sault Ste. Marie—Receipts for the year were about $1,100 in excess of 1920. Mr. Thomas Murphy made an important discovery of gold in Township 28, Range 27, on the Algoma Central Railway. This property is now called the Goudreau Gold Mines, Limited. While this discovery was made on Algoma Central Railway lands, nevertheless, it has a great bearing on the future of the surrounding areas. In Townships 48 and 47, and near Dog lake to the northeast, there was considerable activity in developing gold properties, thus making the Goudreau belt 25 miles in length. At Mile 60 on the Algoma Central Railway the Clark Iron Mining Company have given a contract to the Smith & Travers Diamond Drill Company to drill their iron claims in Township 22, Range 13. If they are successful in locating a body of ore, the Clark Iron Company will open up the mine. In November last a silver discovery was made in Township 188, north of Clear lake, and 28 miles north of the town of Thessalon. A rush started to the vicinity, with the result that the township is pretty well staked. Staking extended to Township 182, to the east of 188.

Kowkash—This Division was neglected almost entirely during the Great War as few miners could be employed; however, returned soldiers appear to be seriously interested in many of the old holdings, and development of the area may be looked for in the near future.

Timiskaming—Most of the prospecting in this Division during the past year was in the township of Bryce, where a discovery of gold was reported in the fall of 1920, and the beginning of 1921. There was less prospecting in 1921 than previously, owing no doubt to economic conditions, but the prospectors are very hopeful and are looking forward to 1922 for better results.

Gowganda—About 65 mining claims were staked for gold during September and October in Rankin and Doon townships, but as very little work has been performed on any of these claims it is too soon to say whether or not the new discovery will prove valuable.

Montreal River—No new discoveries were reported during the year. A large number of the claims recorded during 1921 are re-staking of former claims in Powell and Cairo townships.

Kenora—There has been marked activity in prospecting, as shown by the increase in the number of licenses issued and in the number of claims staked, and there are good indications that the year 1921 will show even a greater activity.

The two tables following show the work done in the offices of the Mining Recorders during 1921, the first table being for the fiscal year ending October 31, and the second for the calendar year.

MONEYS REMITTED BY MINING RECORDERS FOR THE FISCAL YEAR ENDING OCTOBER 31, 1921.

Mining Division*	Name of Recorder	Address	Purchase Price	Permits	Miners' Licenses	Recording fees, etc.	Total
			$ c.	$ c.	$ c.	$ c.	$ c.
Sudbury	Campbell, C. A.	Sudbury	2,986 00	330 00	3,148 50	3,502 25	9,966 75
Porcupine	Gauthier, G. H	S. Porcupine	2,138 28		616 00	1,041 50	3,795 78
	Donaghue, W. A.	S. Porcupine.	1,977 53	70 00	1,087 00	1,906 75	5,041 28
Lardner Lake	Ginn, H Geo.	Swastika	15,085 41		2,401 00	7,586 50	25,072 91
Kenora	Holland, H. E.	Kenora	....		597 00	297 50	894 50
	O'Flaherty, T. F.	Kenora.			3 00	20 00	23 00
Sault Ste. Marie.	Miller, W. N.	Sault Ste. Marie.	873 01	60 00	1,369 00	1,386 97	3,688 98
Port Arthur Kowkash	Morgan, J. W	Port Arthur	1,649 20	50 00	1,812 25	1,472 25	4,983 70
Gowganda Montreal River	Morgan, M. R.	Elk Lake.	1,747 95	630 00	1,250 00	2,304 75	5,932 70
Timiskaming	McAulay, N. J.	Haileybury	664 45	30 00	4,834 00	1,287 25	6,815 70
Total			27,121 83	1,170 00	17,117 75	20,805 72	66,215 30

*The office of the Parry Sound Division was closed Oct. 31st, 1920 and all records transferred to the Department at Toronto

SUMMARY OF BUSINESS OF THE SEVERAL MINING DIVISIONS FOR THE CALENDAR YEAR 1921

Schedule	Sudbury	Porcupine	Larder Lake	S. S. Marie	Pt. Arthur	Kowkash	Timiskaming & Coleman	Gowganda	Montreal River	Kenora	Total
1. Letters received	2,208	1,702	5,544	878	2,141	298	1,476	475	2,055	1,186	17,963
2. Letters written	1,668	1,631	5,291	479	2,098	295	993	375	1,586	1,097	15,513
3. Miners' Licenses issued	288	161	217	232	137	1	254	2	89	100	1,481
4. Miners' Licenses renewed	338	189	314	124	201	16	734	44	121	32	2,113
5. Mining applications recorded	319	273	918	216	120	3	159	101	143	53	2,305
6. Mining applications cancelled	334	194	593	31	66	53	265	98	143	14	1,791
7. Agreements, transfers, etc., recorded	221	202	535	27	46	1	87	27	129	7	1,282
8. Amounts received for Miners' Licenses, Permits, Recording Fees, etc	$6,425 10	$4,379 75	$10,546 25	$3,421 75	$2,817 25	$132 50	$6,201 25	$1,161 50	$3,144 00	$1,011 75	$39,241 10
9. Amount received as Purchase Money or Rentals	$3,041 05	$3,260 42	$9,590 65	$1,779 64	$1,741 25	$254 90	$564 95	$267 55	$1,448 45	....	$21,948 86
10. Claims of which surveyors' plans were filled	43	69	184	11	14	....	3	11	44	....	379
11. Disputes entered	3	1	17	....	1	....	....	....	2	....	24
12. Disputed cases decided by Recorder	2	....	1		....	....		....	2	....	5
13. Appeals to Mining Commissioner	....	....	1	....	....	....	....	....	....	....	1
14. Extensions of time	80	101	265	14	90	6	14	22	100	7	699
15. Certificates of Record	49	58	139	19	21	1	21	8	27	4	347
16. Certificates of Performance of Work	52	64	148	16	21	3	11	10	24	3	352
17. Claims for which papers were forwarded to the Department for issue of title	49	36	120	19	9	3	11	9	10	....	266
18. Forest Reserve Permits issued	....	....		8	3	1	8	8	55	....	83
19. Substitute Miners' Licenses issued	....	....	....	1	1	....	10	....	1	....	13

Mining Revenue

The revenue for the fiscal year ending October 31st, 1921, is given in detail hereunder:

REVENUE FOR THE YEAR ENDING OCTOBER 31st, 1921.

Mining Sales		$25,834 05
RENT—		
Mining Leases	$13,654 78	
Licenses of Occupation	5,208 47	
		18,863 25
Fuel Investigation	8,625 99	
Coal Permits	8,815 05	
		17,441 04
Sand and Gravel Royalty	131,001 31	
Sand and Gravel Rental	3,160 00	
		134,161 31
Miner's Licenses	28,181 10	
Permits	1,240 00	
Recording Fees	22,051 22	
		51,472 32
MINING TAX ACT—		
Acreage Tax	37,581 11	
Profit Tax	183,821 80	
Gas Tax	21,450 01	
Gas Licenses	1,958 82	
		244,813 74
Casual Fees	1,150 39	
Patent Fees	486 36	
Temiskaming Testing Laboratories, fees	3,971 32	
Natural Gas Commissioner's Office, fees	70 00	
Draughtsmen, North Bay, fees	90 15	
Provincial Assay Office Fees	715 00	
		6,483 22
REFUNDS—		
Explorations and Investigations	2,238 83	
Natural Gas Commissioner's Office	476 51	
Mining Recorders	185 00	
		2,900 34
		$501,969 27

MINING LANDS SOLD AND LEASED IN YEAR ENDING OCTOBER 31st, 1921.

District	Sales			Leases			Total		
	No.	Acres	Amount	No.	Acres	Amount	No.	Acres	Amount
			$ c.			$ c.			$ c.
Temiskaming	232	9,445.29	19,434 36	129	3,465.29	568 04	361	12,910.58	20,002 40
Thunder Bay	10	345.25	811 88	9	381.20	381 20	19	726.45	1,193 08
Sudbury	19	735.73	2,010 00	29	1,041.29	723 91	48	1,777.02	2,733 91
Algoma	8	365.78	838 04	....	....	....	8	365.78	838 04
Kenora	1	12.50	15.65	....	....	....	1	12.50	15 65
Rainy River	2	74.00	222 00	....	....	....	2	74.00	222 00
Nipissing	....	....	....	8	307.78	30 78	8	307.78	30 78
Elsewhere	5	207.30	556 50	....	....	....	5	207.30	556 50
Total	277	11,185.85	23,888 43	175	5,195.56	1,703 93	452	16,381.41	25,592 36

Under the Mining Tax Act, a graduated tax is levied on the profits of mining companies in excess of $10,000 per annum. The basal rate is 3 per cent., but there are special provisions for nickel-copper companies. The following statement, prepared by G. R. Mickle, Mine Assessor, gives details of the Profit Tax for the fiscal year ending October 31st, 1921:

DETAILS OF PROFIT TAX.

Gold:		
Hollinger Consolidated Gold Mines, Ltd.,	$76,042 54	
Dome Mines Company, Ltd.,	8,110 77	
McIntyre Porcupine Mines, Ltd.,	8,393 61	
Lake Shore Mines, Ltd.,	1,929 05	
Teck-Hughes Gold Mines, Ltd.,	618 96	
		$95,094 93
Silver:		
Coniagas Mines, Ltd.,	4,656 25	
Cobalt Lake mine (Mining Corporation of Canada)	1,235 42	
Central Operating Co.,	324 11	
Kerr Lake Mining Co. Ltd.,	4,929 86	
La Rose Mines, Ltd.,	591 93	
Miller Lake O'Brien Mine (M. J. O'Brien, Ltd.)	2,342 66	
Nipissing Mining Company, Ltd.,	12,401 44	
		26,481 67
Nickel—Copper:		
International Nickel Co. of Canada, Ltd.,	60,245 20	
Mond Nickel Co., Ltd.,	2,000 00	
		62,245 20
Total		$183,821 80

Mining Companies Incorporated and Licensed

A synopsis of mining companies incorporated and licensed in Ontario during the past decade is given hereunder:

	Incorporated		Licensed	
Year	Number	Capital $	Number	Capital $
1912	130	73,237,000	6	570,000
1913	119	78,000,000	12	21,735,000
1914	80	39,030,000	13	5,445,000
1915	59	42,005,000	2	10,200,000
1916	83	109,079,500	8	7,011,650
1917	100	117,183,000	7	7,202,000
1918	71	49,800,000	7	15,000,000
1919	147	223,530,000	10	9,554,197
1920	119	146,094,000	12	9,435,000
1921	67	105,715,000	6	1,030,000

The mining companies incorporated in 1921 are shown in the list appended, together with head office, date of incorporation and amount of capital authorized.

MINING COMPANIES INCORPORATED IN 1921.

Name of Company	Head Office	Date of Incorporation	Capital
			$
Acton Mines, Limited	Gananoque	April 27	100,000
Allied Porcupine Gold Mines, Limited	Toronto	Feb. 9	5,000,000
Almont Gold Mining Company, Limited	Toronto	June 25	1,000,000
A. L. Shaw Oil and Development Co., Ltd.	Toronto	May 10	500,000
Aster Gold Mines, Limited	Toronto	June 1	2,000,000
Blue Quartz Gold Mines, Limited	Toronto	Nov. 23	3,000,000
British Canadian Petroleum Co., Ltd.	Toronto	April 23	1,000,000
Burnand Gold Mines, Limited	Toronto	Oct. 7	2,500,000
Canadian Non-Metallic Minerals, Ltd.	Opeongo	April 7	40,000
Canyon Mines, Limited	Toronto	Aug. 19	(£) 200,000
Central Ontario Oil Fields, Limited	Peterborough	June 24	1,000,000
Chamberlain Coal and Oil Development Co., Ltd.	Shelburne	Feb. 4	2,000,000
Cities Service Oil Company, Limited	Hamilton	Feb. 11	5,000
Comfort-Kirkland Mines, Limited	Toronto	Feb. 21	1,500,000
Feldspar Glass, Limited	Bowmanville	Sept. 6	1,000,000
Fort Norman Oil Company, Limited	Toronto	Feb. 4	3,000,000
General Petroleum and Gas Company, Limited	Toronto	Mar. 19	500,000
Goldwyn Mines, Limited	Toronto	Oct. 12	2,000,000
Hermo Mining Company, Limited	Cobalt	Aug. 22	40,000
Helogden Mines, Limited	North Bay	Dec. 10	1,000,000
Heltyrex Gold Mines, Limited	Toronto	June 16	3,000,000
International Oil Gas and Development Co., Ltd.	Toronto	Oct. 10	510,000
Islet Exploration Company, Limited	Port Arthur	Jan. 3	250,000
Jackson Development Company, Limited	Port Arthur	Dec. 13	40,000
Kirkland Motherlode Limited	Toronto	June 10	2,500,000
K. M. B. Syndicate	Elk Lake	May 19	100,000
Lakeside Development Company, Limited	Toronto	Mar. 2	100,000
Lebel Lode, Limited	Cobalt	May 13	2,000,000
Lorrain Operating Company, Limited	Toronto	Nov. 24	40,000
Maisonville Mining Company, Limited	Toronto	Feb. 11	2,500,000
Majestic Gold Mines, Limited	Toronto	Jan. 24	1,000,000
Manley-O'Reilly Gold Mines, Limited	Toronto	Sept. 20	3,500,000
Mars Mines, Limited	Toronto	May 28	3,000,000
Matheson Gold, Limited	Toronto	June 16	2,000,000
Middlesex and Dover Oil and Gas Co., Ltd	Toronto	Feb. 7	2,000,000
Mikado Consolidated Mines, Limited	Kenora	Nov. 16	5,000,000
Mono Petroleum Products, Limited	Toronto	May 25	500,000
Montreal-Kirkland Mines, Limited	Kirkland Lake	Nov. 16	2,500,000
Mount Eagle Feldspar Company, Limited	Toronto	Mar. 21	1,000,000
Muir Porcupine Gold Mining Company, Limited.	Toronto	May 9	2,000,000
North Trail Gold Mines, Limited	Toronto	Aug. 13	2,000,000
Noyes Mining Company, Limited	Peterborough	Nov. 14	1,000,000
Porcupine Davidson Gold Mines, Limited	Toronto	Aug. 18	(£)1,000,000
Porcupine Peninsular Gold Mines, Limited	Toronto	July 25	1,000,000
Porter Gold Mines, Limited	Toronto	Sept. 2	2,500,000
Queen Lebel Gold Mines, Limited	Kitchener	May 27	2,000,000
Queenston Quarries, Limited	St. David	Mar. 8	250,000
Rendix Mines, Limited	Toronto	Mar. 5	1,000,000
Ribble Mines, Limited	Toronto	Nov. 24	2,000,000
Royal-Flush Oil and Gas Company, Limited	Toronto	Feb. 9	500,000
St. Anthony Gold Mines, Limited	Toronto	Sept. 9	3,000,000
Sanderson-Kirkland Gold Mines, Ltd.	Toronto	May 30	2,500,000
South Keora Mines, Limited	Toronto	April 14	3,000,000
Storrington Feldspar Company, Limited	Kingston	May 10	100,000
Sydenham-St. Vincent Oil and Gas Co., Ltd.	Owen Sound	Aug. 15	40,000
The American Matachewan Gold Mining Co., Ltd.	Toronto	April 19	1,000,000
The Arkona Gas and Oil Company, Limited	Toronto	May 16	300,000
The Asbestos Pulp Company, Limited	Belleville	Jan. 18	200,000
The Dominion Petroleum Company, Limited	London	May 25	100,000
The Gold Nugget Mining and Development Co., Limited	Sudbury	April 21	500,000
The Grenville Crushed Rock Co., Ltd.	Smiths Falls	Jan. 5	300,000
The McEnaney Gold Mines, Limited	Toronto	Aug. 12	3,000,000

MINING COMPANIES INCORPORATED IN 1921—*Continued*

Name of Company	Head Office	Date of Incorporation	Capital
			$
Toronto-Grey Gas and Oil Company, Limited	Toronto	April 18	600,000
Triplex Gold Mines, Limited	Toronto	June 1	5,000,000
Two-in-One Gold Mines, Limited	Toronto	April 7	5,000,000
Wentworth Oil and Gas Company, Limited	Hamilton	Jan. 19	100,000
West Beaumont Gold Mines, Limited	Toronto	Feb. 26	2,000,000
Total (67 Companies)			105,715,000

Companies of Extra-Provincial incorporation holding mining lands in Ontario are required under The Ontario Companies Act, to take out a license and specify the amount of capital used in Ontario in connection with mining.

Following is a list of the Companies so licensed in 1921:

MINING COMPANIES LICENSED IN 1921.

Name of Company	Head Office for Ontario	Date of License	Capital for use in Ontario
			$
Consolidated Molybdenum Steel Corporation, Ltd.	Renfrew	Mar. 22	500,000
Dickson Creek (Cobalt) Silver Mines, Limited	Haileybury	Jan. 5	100,000
Empire Asbestos Mines Company, Limited	Toronto	May 11	40,000
Hamilton-Bothwell Oil Company, Limited	Hamilton	Jan. 18	300,000
The Eureka Flint and Spar Company, Limited	Kingston	Feb. 24	40,000
Wheeling Feldspar Company, Limited	Burks Falls	Feb. 9	50,000
Total (6 Companies)			1,030,000

Companies which surrendered their charters were as follows:

MINING COMPANY CHARTERS SURRENDERED IN 1921.

Name of Company	Date of Dissolution
British American Metal Company, Limited	Mar. 21
Burlington Steel Company, Limited	Mar. 21
Indian Peninsula Mining Company, Limited	Feb. 14
Petrol Oil and Gas Company, Limited	Feb. 21
The Smiths Falls Malleable Castings Company, Limited	Jan. 31

Provincial Assay Office

The Provincial Assayer, W. K. McNeill, reports as follows for the year 1921:

The Assay Office has been in operation without interruption during the entire year, and the usual variety of work has been done with the assistance of T. E. Rothwell, Chemist and Assayer, and Robert Stewart, Laboratory Assistant.

The work during the year may be classified as follows:

Gold, Silver and Platinum.—1,019 samples were tested and reports issued.

Cobalt and Nickel.—9 samples were tested and reports issued.

Copper.—25 samples. These were mainly from Ontario.

Feldspar.—9 samples were submitted for complete analysis.

Iron Ores.—28 samples were received. A number of these were analyzed for sulphur and phosphorus.

Rocks.—11 samples were received for complete analysis. These were submitted by the geologists of the Department of Mines.

Radium.—68 samples were tested for radio-activity. These were from widely distributed sources, but mainly from Parry Sound and Eastern Ontario.

A large number of samples were brought directly to the Laboratory and if not radio-active, no record is kept.

Identification—152 samples were sent to the Laboratory for identification. Many more were brought direct to the office. Of these latter no record is kept.

Miscellaneous.—71 samples of other minerals were tested. These included lead, zinc, tin, barite, etc. A large number of samples of water were brought to the laboratory to be tested for oil.

Following is a statement of samples assayed free when accompanied by coupons issued by Mining Recorders under the provisions of the Mining Act of Ontario:

Mining Division	Samples received for Free Assay.
Kenora	8 samples for gold, 4 silver, 1 lead.
Fort Frances	5 samples for gold, 1 silver, 2 copper, 1 zinc, 2 nickel.
Kowkash	3 samples for gold.
Parry Sound	1 sample for silver.
Sault Ste. Marie	38 samples for gold, 5 silver, 2 iron, 3 copper, 1 tin.
Sudbury	55 samples for gold, 18 silver, 7 copper, 4 lead, 1 platinum.
Timiskaming	28 samples for gold, 18 silver, 2 copper.
Montreal River	39 samples for gold, 2 silver.
Porcupine	66 samples for gold, 4 silver, 3 nickel.
Gowganda	13 samples for gold, 4 silver.
Port Arthur	45 samples for gold, 7 silver, 1 lead, 10 iron, 2 molybdenum, 1 copper.
Eastern Ontario	4 samples for gold, 2 silver.

The schedule of charges for the Provincial Assay Office and Chemical Laboratory is as follows:

TARIFF OF FEES FOR ANALYSES AND ASSAYS.

1. *Assays:*

Gold	$1 50
Silver	1 50
Gold and silver in one sample	2 50
Platinum Minerals	5 00
Gold and Platinum minerals in one sample	7 00
Separation of Platinum Minerals	Prices on application

2. *Iron Ores:*

Iron (metallic)	$1 50
Silica	1 50
Iron and insoluble residue	2 50
Ferrous Oxide	2 00
Phosphorus	3 00
Sulphur	2 50
Iron, Sulphur, Phosphorus and insoluble	8 00
Manganese	3 00
Titanium	4 00
Complete analysis	Price on application.

3. Limestones, Dolomites, Marls, Clays, Shales:
Determination of:

Insolubles	$1 50
Silica	1 50
Ferric Iron	3 00
Ferrous Iron	2 00
Alumina	3 00
Lime	2 00
Magnesia	2 50
Potash	5 00
Soda	5 00
Alkalies (on one sample)	6 00
Water (combined)	2 00
Moisture	1 00
Carbon Dioxide	2 00
Sulphur	2 50
Phosphorus Anhydrite	3 00

4. Examination of Clay, Shale, or Cement Rock for Cement Manufacture:
Determination of:
Silica, Iron Oxide, Alumina, Lime, Magnesia, Sulphur, and Volatile matter..............................Prices on application.

5. Coal, Coke, Peat, etc.:
Determination of:

Moisture	$1 00
Volatile Combustible	1 50
Fixed Carbon	1 50
Ash	1 50
Sulphur	2 50
Phosphorus	3 00
Caloric value (B.T.U.)	5 00
Ultimate analysis	Price on application.

6. Mineral Waters ....Price on application.

7. Ores and Minerals:
Determination of:

Alumina	$3 00
Antimony	4 00
Arsenic	4 00
Bismuth	4 00
Cadmium	4 00
Chromium	5 00
Cobalt	5 00
Nickel	5 00
Cobalt and Nickel on same sample	6 00
Copper	2 00
Fluorite	4 00
Lead	3 00
Molybdenum	4 00
Manganese	3 00
Tin	4 00
Zinc	3 00

8. Rocks, Complete Analysis ....Price on application.

9. Slags, Sand, etc. ....Price on application.

10. Identification of Minerals and Rocks not Requiring Chemical Analysis......Free

11. Test for Radio-Activity ....Free

Any analytical work not specified in this list will be undertaken on application to the Provincial Assayer.

The pulp of each sample is retained for future reference.

DIRECTIONS.

Samples will be dealt with in the order of their arrival. In every instance specimens and samples should be accompanied by statement specifying the precise locality whence they were taken.

Crushed samples representing large quantities or samples less than five pounds weight may be sent by mail as third-class matter. The name and address of sender should be written plainly on each parcel. Instructions, with money in payment of fees, should be contained in a separate letter. Samples may be sent by express, charges prepaid.

Sample bags addressed to this Laboratory for sending ore pulp by mail may be obtained free on application; also canvas bags for shipping.

Money in payment of fees, sent in by registered letter, post-office order, postal note, or express order, and made payable to the Provincial Assayer, must invariably accompany sample to ensure prompt return of certificate, as no examination is commenced until the regulation fee is paid.

Samples should be addressed as follows:

Provincial Assay Office,
5 Queen's Park,
TORONTO, Ont.

Departmental Correspondence

The volume of correspondence necessary for the work of the Department in all its branches is considerable. Figures supplied by the Files Branch show that for the fiscal year ending 31st October, 1921, communications received numbered 22,198, and communications sent out 23,954. New files issued were 650 and amount paid out for postage was $1,419.

Correspondence in connection with the office of the Minister of Mines is not included, nor is that pertaining to applications for patent or lease of mining lands—the latter files being kept in the Department of Lands and Forests.

GRAVEL DEPOSITS OF THE ST. CLAIR RIVER

By

James Bartlett

In June, 1921, the writer was instructed by Thomas W. Gibson, Deputy Minister of Mines, to investigate the extent of the gravel deposits in the Canadian portion of the Saint Clair river, south of the International Tunnel which joins Sarnia and Port Huron. As the Department of Mines did not wish to have an instrumental survey and borings made this year, the work consisted in ascertaining the approximate positions of the deposits and getting details regarding their magnitude. Six weeks were spent in travelling on the river, locating the positions where gravel boats were dredging and interviewing those likely to have detailed knowledge of the deposits, viz., the officers of some of the gravel companies, the engineers of the Dominion Public Works Department and the masters of the gravel boats. A map was prepared from the information obtained, and it appears as an insert accompanying this report.

Sand and Gravel Definitions and Specifications

The specifications of the Ontario Department of Highways regarding gravel and sand are as follows:

Gravel shall consist of naturally formed fragments of tough, durable rock, well graded in size from the smallest to the largest, free from flat, elongated particles, and shall not contain more than fifteen per cent. by weight of soft, friable material. It shall not contain an excess of clay nor an excess of loose or adhering dust, vegetable loam or other deleterious matter. It shall be satisfactory to the Engineer in all respects.

Run of bank gravel shall be classed according to the following grades:

Grade "A" is a run of bank gravel containing a large percentage of pebbles of igneous rocks. It shall not contain more than 5 per cent. by weight of material which shall be retained on a screen having 4-inch circular openings, and not more than 45 per cent. by weight of material which shall pass a screen having ¼-inch square openings. It shall not contain more than 3 per cent. by weight of clay or loam, nor have a coefficient of wear of less than 14.

Grade "B" is a run of bank gravel containing a smaller percentage of igneous rock pebbles. It shall not contain more than 5 per cent. by weight of material which is retained by a screen having 4-inch circular openings, nor more than 60 per cent. by weight of material passing a screen having ¼-inch square openings. It shall not contain more than 12 per cent. by weight of clay or loam, nor have a coefficient of wear of less than 11.

Grade "C" is a run of bank gravel composed chiefly of pebbles of sedimentary rock. It shall not contain more than 5 per cent. by weight of material which is retained on a screen having 4-inch circular openings, and not more than 80 per cent. by weight of material which passes a screen having ¼-inch square openings. It shall not contain more than 12 per cent. by weight of clay or loam, nor have a coefficient of wear of less than 7.

Grade "D" is a run of bank gravel which does not meet the requirements of any of the above grades, and which may be used only by written permission of the engineer.

Gravel for Gravel Roads.—Gravel is to be clean, moderately coarse and free from an excess of clay, sand or earthy material. The best gravel for roads consists of about 75 or 80 per cent. stone and pebbles, about 10 per cent. coarse sand, and the remainder clay or loam.

Concrete Sand.—Fine aggregate for concrete shall consist of natural sand composed of hard, tough, durable particles graded from fine to coarse. When dry, not more than 6 per cent. shall be retained on a sieve having 4 meshes per lineal inch; not more than 20 per cent. by weight shall pass a sieve having 50 meshes per lineal inch; and not more than 4 per cent. shall pass a sieve having 100 meshes per lineal inch. It shall not contain more than 3 per cent. by weight of clay or loam.

Sand for Bituminous Construction.—Sand for use in bituminous pavement construction shall consist of hard, tough, durable particles. It shall not contain more than one per cent. of clay or loam. The various types of grains present shall be as closely as possible in the following proportions by weight:

Percentage of Sand	Pass	Retained on
30	8-mesh sieve	30-mesh sieve
27	30 " "	50 " "
30	50 " "	80 " "
15	80 " "	100 " "
7	100 " "	200 " "
1	200 " "	...

In Bulletin No. 37, Geological Survey of Georgia, "Preliminary Report on the Sand and Gravel Deposits of Georgia," by L. P. Teas, the following definitions and classifications are given:

> Sand consists of fine particles of crushed or worn rock. . . . We may define sand as an incoherent material made up of grains ranging from 1/150th of an inch to ¼-inch in size. Unconsolidated material whose grains lie between 1/100th and 1/250th of an inch, is known as silt; and if the grains fall below 1/250th of an inch we have clay or mud.
>
> When the grains of any natural, unconsolidated substance become larger than ¼ inch in diameter, the term gravel is applied to them.

According to Dake[1] the following terms applied to gravel are widely used in Missouri:

Sand....................Through ⅛ inch.
Torpedo Gravel.........Through ¼ inch on ⅛ inch, also called Torpedo sand.
Roofing Gravel..........Through ¾ inch retained on ¼ inch.
Binder Gravel...........Through 1½ inch on ¼ inch.
Concrete Gravel.........Through 2½ inch on 1½ inch

Condra[2] considers three sizes of sand:

Fine Sand..............0.5 mm. or 0.02 inch in diameter.
Medium Sand...........2.0 mm. or 0.08 " " "
Coarse Sand............5.0 mm. or 0.20 " " "

In Memoir 85 of Canada, Geological Survey, "Road Material Surveys in 1914," L. Reinecke, the author says, on page 35:

> In the specifications adopted by the American Concrete Institute for concrete highways it is recommended that the coarse aggregate should be such as would pass a 1½-inch round opening and be retained on a screen having ¼-inch openings; and the fine, that which would pass when dry through a screen with ¼-inch openings. Not more than 20 per cent. of the fine shall pass a screen having 50 meshes per linear inch, and not more than 5 per cent. a screen having 100 meshes to the linear inch. It is recommended that not over 40 per cent. of the total aggregate used be fine, and that not more than 5 parts of total aggregate be used to 1 of cement. Vegetable matter, loam and clay are a source of weakness in concrete, and the Institute recommends that not more than 3 per cent. of the aggregate should consist of these impurities.

---

[1] Dake, C. L., The Sand and Gravel Resources of Missouri: Missouri Bureau of Geology and Mines, Volume XV, Page 7, 1918.

[2] Condra, G. E., Sand and Gravel Resources and Industries of Nebraska: Nebraska Geological Survey, Volume III, Part 1, Page 29, 1908.

Origin of the Deposits

Most of the gravel has been borne by the river from Lake Huron, where it was doubtless obtained from the erosion of the shores which are said to consist largely of glacial deposits. A small percentage of the material may come from streams flowing into the St. Clair river.

No articles have appeared giving the rate at which the east shore of Lake Huron is being eroded, but Leon J. Cole, of Michigan Geological Survey, in an instructive paper on the St. Clair delta, mentions the following with regard to the erosion of the west shore:

> That the source of sediments (in the St. Clair delta), is not confined to the east shore of Lake Huron is shown by the work of C. H. Gordon,[1] who studied the destructive action of the waves at a point on the west shore some fifteen miles north of Port Huron. By comparison of surveys made in 1823 and in 1901, Gordon finds that one estate, which contained 184.90 acres at the earlier date, with a water front of something less than a mile, lost in the intervening seventy-nine years, 27.25 acres of land, which was washed away and carried into the lake by wave action—an average of 0.345 acres per annum. The total average recession of the shore line within this area was 449.46 feet, or an average recession of 5.7 feet per annum. The amount of material was 878,944 cubic yards, and it is safe to assume that a great deal of this eventually found its way into the St. Clair river, both on account of the direct wave action along the beach, as on the eastern side, and by the shore currents, which on this side run close to the shore and would catch the lighter materials, that did not sink at once to the bottom. It is important to note the character of the sediments contributed at this place, where the bluff twenty feet in height gives a good section of the glacial deposits which compose the land. According to Gordon the section is made up as follows:

	Feet	Inches
1.—Soil—top loam	1	6
2.—Light coloured or drab Sandy soil, small pebbles	9	9
2*a*—Brownish band: apparently a soil horizon	.	6
3.—Blue clay; more compact than No. 2*a*	7	0
4.—Blue clay; darker and more compact than No. 3	4	0

The gravel deposits are found at intervals in the river, from Lake Huron to the channels emptying into Lake St. Clair. As a rule they occur in the form of long and comparatively narrow bars whose longer axes are parallel to the direction of flow. The current of the river is estimated to be 4½ miles per hour and less, its greatest velocity being at Point Edward. The lessening of the current, when Lake St. Clair is reached, has resulted in the precipitation of large quantities of silt and clay and the formation of the St. Clair delta. As might be expected, the coarser gravel is found in the upper reaches of the river, the pebbles becoming smaller and fewer and the sand more abundant as the river is followed south, until in the vicinity of Algonac the deposits consist either of "torpedo" gravel or of sand.

In the journey down stream the coarser particles roll along the bottom and the lighter sediments are suspended in the water. Divers report that opposite Point Edward their work is at times rendered difficult by the bombardment of pebbles carried by the current and suspended in the water. In times of storms, particularly with winds blowing from a northerly direction, the amount of material swept from the lake into the river at Point Edward is greatly increased. The movement of vessels, especially the large freight boats drawing up to twenty feet of water, exerts a considerable influence in assisting the gravel down stream. Ice and wave action also probably assist to some extent.

There is but little gravel digging being done this summer in the United States portion of the St. Clair river. Whether this is due to there being little gravel left, or whether the deposits are being kept for future use, I was unable to learn, but the difficultly of dealing with the owners of the riparian rights is probably a deterring factor. The digging of sand and "torpedo" gravel is practically all being done in United States waters, viz., in the North Channel, the Middle Channel, and Chenal à Bout Rond. It is possible that important deposits of torpedo gravel occur in Canadian water, but little search seems to have been made for them.

---

[1] Wave Cutting on West Shore of Lake Huron, Sanilac County, Michigan, Report Michigan Geol. Survey for 1901, Lansing, 1902.

Rate of Growth of the Deposits

Opposite Point Edward and Sarnia the deposits shift rapidly: this necessitates frequent surveys by the engineers of the Canadian and United States Governments in the interests of navigation. Dredging is done by both Governments in their respective halves of the river and has been carried on annually for many years. Of late years the shoals in the Canadian portion of the river at these points have been removed by gravel-dredging licensees under the supervision of the engineers of the Dominion Public Works Department. As most of the material on the two principal deposits, which are known as the "Point Edward" and "Sarnia" shoals, has been of commercial value, the dredging companies are glad to do this dredging free, paying the Province of Ontario royalties on the gravel sold and furnishing certain municipalities in Western Ontario with stipulated quantities of gravel at less than cost.

Self-loading Boats Dredging Gravel Below the "Tunnel," St. Clair river

During 1919, the Point Edward "shoal," which lies beside the Northern Navigation Company's dock at Point Edward, increased by 5 to 7 feet in thickness; in July, 1920, this shoal built up 4 feet at one spot in three weeks. It is the opinion of the engineers of the Public Works Department that the percentage of sand on the Point Edward "shoal" and the Sarnia "middle ground" is increasing. Whereas there used to be plenty of gravel above the 23-foot depth, there is said to be but little to-day. In order that the cross-section of the river may not be increased, and the level of Lake Huron lowered, gravel boats are not permitted to dig to a greater depth than 23 feet in front of Point Edward and Sarnia.

With regard to the rate of increase of the deposits south of the International Tunnel, no exact information is obtainable, but it is generally agreed that the annual increment is small.

The Gravel Boats

To illustrate the size of some of the boats engaged in gravel dredging the following examples are cited:

	Gross tonnage	Net tonnage	Capacity, cubic yards
Str *F. E. Harvey*	355	288	340
“ *C. W. Cadwell*	593	212	860
“ *Chas. Heiden*	717	446	625
“ *John M. McKerchey*	443	161	732
Barge *Whale*	1,144	1,144	1,850
Str. *Harsen*	...	...	700
“ *Ontario*	...	...	275
“ *F. C. Osborne*	. .	...	600

On most of the boats the dredging is done with 1½ cubic yard clams, but in a few cases a 1¼ cubic yard size is used. In addition to the clam some of the boats carry a centrifugal pump for winning the gravel. The Str. *John M. McKerchey* has no clam, but is equipped with a Morris centrifugal pump connected to a 10-inch suction; this boat carries a crew of 16 men.

Gravel Boat Leaving Dredge After Being Loaded, St. Clair river

Results of Screen Tests

Eight samples of gravel and sand were obtained from the portions of the river mentioned below, and were sent to the Ontario Highways Department testing laboratory for screen-tests:

Sample 1—Gravel from Point Edward shoal.
2—Gravel from deposit J about 1¼ miles north of Sombra village.
3—Sand from a cargo dug in the North Channel.
4—Gravel from Point Edward.
5—"Torpedo gravel" or coarse sand from a cargo dug in the Middle Channel, some four miles below Algonac.
6—"Torpedo gravel" dug in U.S. waters in front of Algonac.
7—Gravel from deposit 1, which is opposite concession III, township of Moore.
8—Gravel from deposit "A" in front of Mueller's Brass Works, Sarnia, and a few hundred feet south of the International Tunnel.

The laboratory tests are given in the Appendix at the end of this report.

Pebbles

As the mineralogical composition of gravels is of importance, I examined the coarser pebbles (roughly ¾-inch and upwards) in the above mentioned samples and found the number and kind of these pebbles to be as follows:

Kind of Rock	No. 1	No. 2	No. 4	No. 6 pebbles over ½-inch	No. 7	No. 8
Limestone	43	11	26	....	34	54
Dolomite	21	2	29	1	15	7
Chert	12	18	3	2	20	19
Cherty dolomite	1	....	1	....	2	1
Cherty limestone	....	....	....	....	2	3
Quartzite	9	1	5	1	6	7
Arkose	3	1	5	....	2	3
Granite	7	2	6	....	13	7
Greenstone	5	1	....	....	2	....
Granite Gneiss	1	....	1	....	....	1
Green Slate	1	....	....	....	....	....
Diorite	1	....	....	....	1	....
Shale	....	4	....	....	10	2
Greywacke	....	2	....	7	6	2
Hornblende syenite	....	1	....	....	1	....
Syenite	....	....	7	....	1	1
Conglomerate	....	....	2	....	....	1
Red quartzite	....	....	1	....	....	....
Sandstone	....	....	....	....	6	....
Trap	....	....	....	....	1	....
Slate	....	....	....	....	1	....
Quartz schist	....	....	....	....	....	1

Selling Prices of the Gravel

Detroit.—The United Fuel and Supply Company is the largest dealer in sand and gravel in Detroit. It obtains gravel from the St. Clair river and also from seven pits within 25 miles of Detroit. This Company's retail price list of July 20, 1921, quotes the following prices per cubic yard on less than car lots:

Sand, river or washed, screened, flat or sharp:

District 1	District 2	District 3	District 4
$2.65	$3.00	$3.50	$3.75

Gravel for concrete:

District 1	District 2	District 3	District 4
$2.65	$3.00	$3.50	$3.75

Roofing gravel—any district—per ton, $2.75.

The boundary of district No. 1, is roughly a mile and a half from the Detroit river. The above prices are subject to a 5 per cent. discount, 30 days.

Windsor.—In Windsor the retail price of sand and gravel in small lots is $3.50 per cubic yard for all points less than a mile away from the docks; outside the one mile radius the rate is $3.25. Fifty cents more per yard is charged if the gravel is screened. Algonac "torpedo gravel" sells here for $3.50 per cubic yard in small lots. The discount in Windsor is 7 per cent., 30 days.

The prevailing practice in both cities is to call material below ¼-inch sand. Most of the sand is sold as "flat" or "sharp." The "flat" sand is fine and suitable for mortar or plaster; the "sharp" is coarse, such as is obtained in the North Channel and near Algonac, and is particularly suitable for the manufacture of concrete blocks.

Details of the Deposits

The map which accompanies this report was compiled from Lake Survey charts and Department of Militia maps. On this the information obtained from those engaged in dredging gravel was plotted, the several deposits being distinguished by letters. As even those who have been dredging gravel for years do not, as a rule, possess accurate information about the deposits, it necessarily follows that the outlines of the deposits, as shown, are by no means exact. The following notes regarding the deposits are a compilation of the data obtained

from 40
Tunnel;
lay has
engaged
in this

Survey
ago.
six feet
ly more
getting
stream

wel, but
ether it
om 2 to

e of the

This
of about
worked

Middle
is now

It is
yard.
rgest de-
in thick-

hipyard.
et thick.
consider-

to have
n stated
onsider-

worked

ug from
ring my
stay. The gravel was said to have been 8 or 10 feet thick in the Canadian portion and some may still remain, but the U.S. portion is believed to be about exhausted.

PROVINCE OF ONTARIO
DEPARTMENT OF MINES

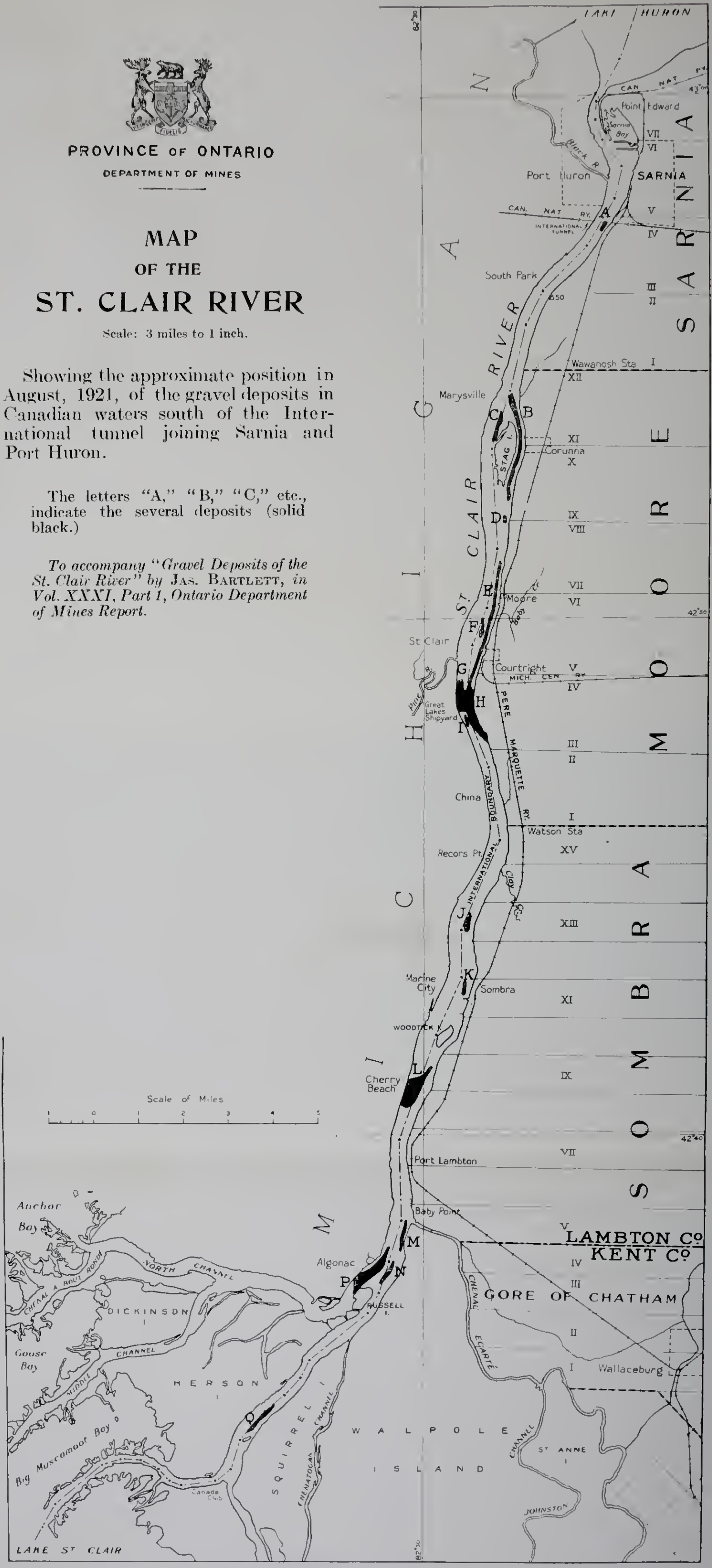
MAP
OF THE
ST. CLAIR RIVER

Scale: 3 miles to 1 inch.

Showing the approximate position in August, 1921, of the gravel deposits in Canadian waters south of the International tunnel joining Sarnia and Port Huron.

The letters "A," "B," "C," etc., indicate the several deposits (solid black.)

To accompany "Gravel Deposits of the St. Clair River" by Jas. Bartlett, *in Vol. XXXI, Part 1, Ontario Department of Mines Report.*



tinguished by letters. As even those who have been dredging gravel for years do not, as a rule, possess accurate information about the deposits, it necessarily follows that the outlines of the deposits, as shown, are by no means exact. The following notes regarding the deposits are a compilation of the data obtained from various sources:

"A"—In front of Mueller's Brass Works, Sarnia: This deposit is from 40 to 80 feet wide, and extends for 1,000 feet south of the International Tunnel; it is from 3 feet to 6 feet thick, but at some points the underlying clay has been bared. Much of the gravel here was probably dumped from scows engaged in dredging the channel. Sticks and balls of mud are quite numerous in this deposit.

A couple of miles south of the Tunnel and north of Boundary Survey Monument No. 50, there was a four-foot bed of gravel some four years ago.

"B"—East of Stag island. This deposit was at one time five or six feet thick, but is now nearly worked out, and where gravel remains it is rarely more than one bucket, or three feet, in thickness. One captain told me that in getting a load recently from the central part of this bar he had to drop down stream in all 800 feet.

"C"—West of Stag island. This deposit consisted of fairly good gravel, but carried considerable sand. Some uncertainty was expressed as to whether it extends west into deep water or not; one captain states that it was from 2 to 8 feet thick, about 90 feet wide and is now almost exhausted.

"D"—This is a small deposit near Stag Island Lower Light. None of the captains interviewed had dug here of late years.

"E"—Extends from a mile north of Moore to south to Courtright. This bar was formerly from 2 feet to 8 feet in thickness, with an average of about 6 feet and was about 250 feet in width. Most of this deposit is now worked out, particularly that portion which lies above Courtright.

"F"—Is situated west of Deposit "E" and east of the St Clair Middle Ground. It is said to have been at one time 14 or 15 feet thick, but is now nearly depleted.

"G"—Is a deposit in U.S. waters whose dimensions I did not learn. It is said to extend from above the town of St. Clair to the Great Lakes shipyard.

"H"—Is a extension of "E" to the south. This was one of the largest deposits in the river and consisted of a fairly coarse gravel up to 12 feet in thickness. It is now said to be from 0 to 4 feet thick.

"I"—Is a small deposit in U.S. waters south of the Great Lakes shipyard. This consists of coarse gravel and is about 40 feet wide, and 4 or 5 feet thick. The material in Canadian water east of this point in "H" deposit is considerably finer.

"J"—Is opposite concession XIII, Sombra township. This is said to have been from 8 to 10 feet thick and some 800 feet in width. One captain stated that it probably had been 20 feet thick at the International Boundary. Considerable digging was still being done on this deposit this summer.

"K"—Is a small deposit in front of Sombra village. It is practically worked out, but was formerly 1,000 feet long and up to 6 feet thick.

"L"—Is south of Woodtick island. A great deal of gravel was dug from this deposit in past years, but not a boat was seen loading here during my stay. The gravel was said to have been 8 or 10 feet thick in the Canadian portion and some may still remain, but the U.S. portion is believed to be about exhausted.

"*M*"—This bar, south of the head of the *Chenal Écarté,* consists of sand and "torpedo gravel" with the former predominating. The thickness is not known.

"*N*"—Is south of "M" and northeast of Russell island. It is said to be 8 or 9 feet thick, and to consist largely of "torpedo gravel."

"*P*"—Is in front of Algonac and consists of sand and "torpedo gravel." It is said to be getting thin.

"*Q*"—Is situated about three miles north of the Canada Club. It consists of "flat" (plaster) sand and it is stated that a load can be pumped at any point on the deposit without changing the boat's position.

From Algonac to Lake St. Clair, via the North Channel, large deposits of "torpedo gravel" and of sand are reported. Sand is also dug in the Channel known as the Baltimore Highway. The bed of the Middle Channel is said to be covered with sand throughout most of its course.

Gravel Tests

Mr. H. E. Davis, Testing Engineer, Department of Public Highways, under date of September 14th, 1921, reported to the Department of Mines on the eight samples of gravel submitted, as follows:

> In accordance with your request regarding samples of gravel submitted for test, I am attaching copies of Reports giving the granulometric analysis, and ratio of sand to gravel. The colorometric test was satisfactory in all cases.
>
> All of these samples would be considered suitable aggregates for concrete work. It will be noted, however, that in the case of sample No. 3, there is no gravel present and for making satisfactory concrete this addition would have to be made. The silt and organic matter apparently has been washed free from all eight samples.

For convenience these separate reports have been arranged in tabular form.

Mechanical Analysis	Sample No.							
	1	2	3	4	5	6	7	8
SAND								
Percentage retained on								
10 mesh screen	30.0	37.4	1.0	46.4	43.4	48.8	40.4	57.4
20 " "	63.0	44.0	6.0	75.4	61.6	65.4	51.8	73.0
30 " "	84.0	47.8	18.0	89.0	69.6	71.0	57.8	80.0
40 " "	93.0	53.2	38.8	95.0	78.0	76.0	65.0	86.6
50 " "	97.0	66.2	66.4	98.8	90.4	85.2	75.6	92.4
100 " "	99.0	97.2	96.0	99.8	99.0	99.2	96.8	99.0
200 " "	99.6	99.8	99.6	99.9	99.9	99.9	99.2	99.6
GRAVEL—								
Percentage retained on								
1-1/4 inch screen	14.2	......	......	10.6	......	......	13.5	2.5
7/8 " "	18.2	......	......	14.5	......	......	23.6	10.0
3/4 " "	27.5	1.2	......	19.9	0.9	......	33.5	21.7
1/2 " "	38.0	8.9	......	42.4	1.9	0.6	50.0	39.7
1/4 " "	53.0	30.3	......	63.1	9.0	11.9	72.2	64.2
PERCENTAGE RATIO:								
Sand	47	69.7	......	36.9	91	88.1	27.8	35.8
Gravel	53	30.3	......	63.1	9	11.9	72.2	64.2

Future Demand for the Gravel

As Essex, Kent and Lambton counties contain but few gravel pits and very few rock outcrops, there is a constant and increasing demand for river gravel for road building and general construction work. There is no doubt that this demand will continue to increase, as the building of good roads in these counties has been under way for comparatively few years.

Conclusions

The following conclusions have been reached regarding the gravel deposits south of the Tunnel:

1. That the deposits are being rapidly depleted and that many of them are worked out or the gravel remaining is so thin that digging is no longer profitable.

2. That the annual increment south of the Tunnel is comparatively small.

3. That there are probably some, but not many, deposits which have not been found.

4. That no estimate can be made as to how much longer digging can be carried on at the present rate unless a hydrographic survey be made and borings put down at frequent intervals. I do not believe that the deposits warrant the expenditure.

Acknowledgments

I wish to express my appreciation of the courtesies shown me and the assistance given by Messrs. H. B. R. Craig and John Graham, engineers of the Public Works Department, the officers of the United Fuel Company and the Chick Contracting Company, and particularly by Mr. Thos. W. Whiteley, inspector of dredging operations for the Ontario Department of Mines.

INDEX VOL. XXXI, PART I

Note—All place names refer to Ontario unless otherwise mentioned.

PAGE
Abitibi Power and Paper Co........ 41
Abrasives. *See* Corundum.
Acheson Graphite Co.............. 22
Acme Gold Mines, Ltd............. 7
Acreage tax, revenue.............. 46
Actinolite.
  Industry and statistics...........2-20
Actinolite Mining Co.............. 20
Acton 35
Acton Mines, Ltd.................. 48
Addington Co. *See* Lennox and Addington Co.
Alabastine Co..................... 37
Aladdin Cobalt Co..................8, 13
Aldborough tp., sand and gravel...38, 39
Aldershot 31
Alfred, peat....................... 25
Algoma dist.
  See also Iron ore: Quartz.
  Mining lands sold and leased..... 46
  Sand and gravel................. 41
  Trap. *See* Bruce Mines.
Algoma Steel Corporation..........17, 18
  See also Iron pyrites.
  Quartz Mining.................. 27
Algonac 55, 57, 60
Allan, Mrs. M.................... 38
Allan Bros........................ 38
Allied Porcupine Gold Mines, Ltd.... 48
Almont Gold Mg. Co. 48
A. L. Shaw Oil and Development Co. 48
Alvinston 30
Alvinston Brick and Tile Co......... 30
Amabel tp. *See* Wiarton.
American Cyanamid Co.............. 37
American Matachewan Gold Mg. Co. 48
American Smelting and Refining Co. 12
American Talc Corporation......... 28
Amherstburg.
  Concrete products................ 35
  Limestone quarry................ 42
  Salt 27, 28
Analyses.
  Charges for..................... 50
  Gravels, St. Clair river.......... 60
Ancaster 42-43
Ancaster tp. *See* Ancaster: Hamilton.
Anderdon tp., lime kilns........... 37
Andrews, S. J..................... 34
Anthistle, W. J................... 34
Antimony 12
Apatite production (1919)......... 3
Argonaut Gold, Ltd................ 5
Arkona Gas and Oil Co............. 48
Armstrong Supply Co............... 38
Arnprior 30
Arsenic.
  Price; statistics................2, 3, 12
Arthur tp., concrete products........ 34
PAGE
Asbestos production (1917)......... 3
Asbestos Pulp Co..................28, 48
Ashman, T. J...................... 34
Ashton and Sons, E................ 38
Assay Office, Provincial—
  Report by W. K. McNeill.........49-53
Aster Gold Mines, Ltd.............. 48
Atikokan 17
Atikokan Iron Co.................. 18
Atlas Brick Co.................... 30
Ayr 40

—B—

Bailey Silver Mines, Ltd........... 8
Baird and Son, H. C............... 30
Baker, Geo. C..................... 30
Baker, M.......................... vi
Ballast, railway................... 38
Banks, John....................... 34
Bannerman, Geo. (Jr.)............ 30
Baptiste lake..................... 20
Barite 3, 20
Barnhardt, W. H.................. 30
Barrie 40
Bartlett, James................... vi
  Report by, on gravel deposits of St. Clair river...............53-61
Barton tp.
  Lime kilns...................... 37
  Limestone quarrying............. 43
  Sand and gravel................. 39
Bartonville 36
Bathurst tp., feldspar............. 21
  Quartz 27
Bawden, F. W..................... 34
Bayonne, N. J....................15, 17
Beachville 37, 43
Beachville White Lime Co.......... 37
Beaver Consolidated Mines, Ltd.....8, 13
Beaverton 32
Bechtel, B. E..................... 30
Beckwith tp., limestone............ 43
Bedford tp., feldspar.............. 21
  Mica 24
Belle River....................... 25
Belleville 32, 33
Bellew, H. C...................... 20
Bellyou, Norman E................. 38
Belmont tp., limestone............. 43
Bennett, Joseph................... 38
Bennett, N. W..................... 8
Bennett, Robert................... 30
Benson, G. H...................... 8
Benson and Patterson.............. 38
Benzine production................ 26
Bergin, Patrick................... 37
Bertie tp., limestone.............. 43
Beuglas, James.................... 34
Beverley tp., lime kilns............ 37
Biederman, A. G.................. 37
Bishop, Thos. Wm.................. 34
Black Donald Graphite Co.......... 22
Blair and Son, James.............. 39

Page
Blanshard tp. *See* St. Marys.
Blast furnaces 17-19
Blast sand 38
Blenheim 31
Blister copper, production 16
Blue Quartz Gold Mines, Ltd 48
Bluevale 31
Blyth 31
Bolton 32
Bonuses paid by silver mining companies 13, 14
Booth Brick and Lumber Co 30
Bothwell 25
Bout Rond Channel 56
Bowers, E. G 34
Bowmanville 30, 31
Boyd Bros 39
Brampton 30
Brampton Pressed Brick Co 30
Brant county. *See* Brantford tp.; Dumfries N. tp.
Brant tp., limestone 43
Brantford tp.
  Brick 31
  Gravel and sand 39
Brick.
  Industry and statistics 2, 29-32
Brick, concrete 33
Brick, sand-lime 38
Brick, silica. *See* Silica brick.
Bridgeport 40
Bridgden, Henry 34
Bright 34
Bristol tp 43
British American Metal Co 49
British America Nickel Corp 15, 17
British American Oil Co 26
British Canadian Petroleum Co 48
Broadwell and Son, B 30
Brock tp., gravel and sand 39
Brougham tp., graphite 22
Brown, D. L 34
Brown and Sons, Wm 39
Brownscombe, H 30
Bruce, E. L vi
Bruce co., limestone quarries 42, 43
Bruce Mines, trap 42
Bruce nickel mine 15
Bruce tp 44
Brunner Mond, Canada, Ltd 27, 28, 37, 42
Buck, J. L 30
Bucke tp., limestone 42
Buffalo silver mine 9
Buffalo Mines, Ltd 13
Building Material. *See* Structural material.
Building stone. *See* Stone, building.
Bureaus of Statistics, Dominion 1
Burgess North tp.
  Barite 20
  Graphite 22
  Mica 20, 24
Burkholder, George 34
Burlington 35
Burlington Heights 39
Burlington Steel Co 49
Burnand Gold Mines, Ltd 48
Burrows, A. G vi
Butler 43

Page
—C—
Cadwell Dredging Co 41
Calcite 20
Calcium arsenate 12
Calder, James 34
Caldwell, Ont 23
Caldwell, T. B 20
Caldwell Bros 42
Caledon tp 38
Caledonia.
  Concrete products 34
  Gypsum 22
Camburn Silver Mines, Ltd 9
Cameron Steamship Co 41
Camlachie 35
Campbell, A. C 44
Campbellford.
  Lime kilns 37
  Sand and gravel 39, 40
Campbell's Sons, R 29
Campbellville 35
Canada Cement Co 33
Canada Lime Co 37
Canadian Concrete Products Co 34
Canadian Furnace Co 18
Canadian General Electric Co 30
Canadian National Clay Products Association 29
Canadian Non-Metallic Minerals, Ltd. 21, 48
Canadian Oil Companies, Ltd 26
Canadian Pressed Brick Co 30
Canadian Salt Co 27, 28
Canadian Steel Corporation 18
Candles, production 26
Canyon Mines, Ltd 48
Capital issue of new companies 47-49
Cargill 30
Carleton co.
  Limestone quarrying 42-43
  Sand and gravel 39
Carleton Place, brick 31
Carroll, J. E 41
Carroll Bros 39
Casey tp., silver 8, 11
Casey Cobalt Silver Mining Co 13
Cast Stone Block and Machine Co 34
Caustic soda 27
Cayuga 35
Cement, Portland.
  Industry and statistics 2, 3, 33-36
Cement, precious metals 17
Centralia 31
Central Ontario Oil Fields, Ltd 48
Central Operating Co 47
Chamberlain Coal and Oil Development Co 48
Chambers-Ferland silver mine 8
Chapman, John 30
Chatham, concrete products 34, 37
Chatham Cement Tile and Block Co. 34
Chatham Sand and Gravel Co 41
Cheeseman, Peter 30
Chenal à Bout Rond 56
Chenal Ecarté 60
Chick Contracting Co 41, 61
Chinguacousy tp., sandstone 43
Chitty and Johns 9
Christie, Henderson & Co 37

Page
Christie Concrete Products, Ltd. 34
Chrome, N. J. 12
Cities Service Oil Co. 26, 48
Clarendon tp., lime kilns 37
Clark Iron Mining Co. 44
Clarkson Cement Tile and Brick Co. 34
Clay products.
  Industry and statistics 2, 3, 29-32
Cleary, Thomas 39
Clinton 34
Clydach, Wales 16
Coal permits 46
Coatsworth 31
Cobalt.
  See also Cobalt, Ont., silver.
  Price of metallic 11
  Statistics 2, 4, 10, 12
Cobalt, Ont.
  Silver and cobalt 8-14
Cobalt silver area, production 9
Cobalt Central Mines Co. 13
Cobalt-City Mining Co. 13
Cobalt-Comet Mines, Ltd. 13
Cobalt Lake silver mine 9, 47
Cobalt Lake Mining Co. 13
Cobalt Townsite Mining Co. 14
Coboconk, lime 37
Cobourg, brick 31
Cochrane dist.
  Sand and gravel. *See* Rickard tp.
Cody tp. 43
Coehill, granite 43
Coldwater 43
Cole, G. E. vi
Cole, Leon J. 55
Coleman tp., silver 8-14
Colonial Mining Co. 9
Comber, brick and tile 31, 32
Comfort-Kirkland Mines, Ltd. 48
Concrete, brick 33
Concrete Pipe and Products Co. 34
Concrete sand.
  Definition by Highways Dept. 54
Condra, G. E. 54
Conestogo, brick and tile 32
Coniagas Mines, Ltd. 9, 13, 17
Coniagas Reduction Co. 11
Coniagas silver mine 8
Conlon, John J. 39
Consolidated Molybdenum Steel Corp. 49
Construction and Paving Co. 37
Cooksville Shale Brick Co. 30
Cooper, W. H. 30
Copper.
  See also Nickel.
  Statistics 2-4, 10-16
Corinthian Stone Co. 34
Correspondence, departmental 52
Corundum, statistics 2, 3, 20
Corundum, Limited 20
Cottam 34
Cotterill, Alfred A. 39
Courtright, gravel 59
  Salt 28
Craig, H. B. R. 61
Crang, Jethro 30
Crawford Brothers 30
Crediton, brick 31
Creighton nickel mine 15
Cross and Wellington 22

Page
Cross Builders' Supply Co. 34
Crosthwaite, F. 39
Crown Gypsum Co. 22
Crown Reserve Mining Co. 9, 13
Crown Reserve silver mine 9
Crystalline, limestone, operators 42
Cudmore, J. W. 39
Curtin, Frank 30

—D—

Dake, C. L. 54
Dalton, Maurice 30
Darlington tp., sand and gravel 40
Davis, H. E. 60
Davis and Son, John 29
Dean, Harry F. 39
De Laplante, J. E. & Co. 30
Deline, L. 34
Deller, Albert E. 31
Deller, Wm. H. 31
Deller Bros. 31
Deloro Smelting & Refining Co. 11, 12
Denny, James J. vi.
Department of Public Highways.
  Limestone quarrying 42
  Sand and gravel specifications 54
Dept. of Railways and Canals 41
Departmental correspondence 52
Dereham tp., sand and gravel 39
Deroche tp., quartz quarry 27
Deseronto, blast furnace 18
Dewitt, W. J. 34
Dickens tp., feldspar 21
Dickson Creek (Cobalt) Silver Mines, Ltd. 49
Dill tp., quartz 27
Dillon and Mills 21
Dividends.
  Gold mines 6, 7
  Silver mines 13, 14
Dog lake 41
Doidge, James A. 34
Dolan, John 31
Dolly Varden, lime 37
Dolomite industry 20, 42
Dome gold mine 43
Dome Extension gold mine 7
Dome Mines Co. 5, 7, 47
Dominion Bureau of Statistics 1
Dominion Petroleum Co. 48
Dominion Reduction Co. 9
Dominion Salt Co. 28
Dominion Sewer Pipe and Clay Industries, Ltd. 29, 31
Dominion Sugar Co. 37
Donaghue, W. A. 44
Donald, Andrew 39
Donaldson, S. E. 31
Donaldson, W. J. 39
Don Valley Brick Works 31
Dorchester Station 31
Dover, West, oil field 25
Downie tp., sand and gravel 4
Doyle, William 39
Drain tile 30-32
Draper tp., granite 43
Dredging. *See* St. Clair river.
Dresden, brick and tile 30, 31
Drummond tp., feldspar 21
  Quartz 27

Page
Drury tp., limestone........ 43
Dublin 31
Dublin Brick and Tile Co........ 31
Dumfries North tp.
  Limestone 43
  Sand and gravel........ 40
Dundas, limestone........ 43
Dunnville.
  Brick and tile........ 30
  Concrete products........35, 42
Dunsford, concrete products........ 34
Dunwich tp., sand and gravel........ 40
Durham co., sand and gravel........ 40
Dutton, oil........ 25
  Tile 31
Dysart tp. *See* Haliburton.

—E—

Ecarté channel........ 61
Edward pt........55-57
Elarton Salt Works Co........ 28
Eldon, limestone........ 42
Electrolytic copper, production........ 16
Elgin co.
  See also Aldborough tp.
  Sand and gravel........39, 40
Elk Lake, silver........ 8
Ellice tp., sand and gravel........ 40
Elliott, Charles........ 31
Elliott, J. A........ 34
Elliott, Jas., Jr........ 31
Elliott, Wm........ 31
Elliott, Wm. M........ 24
Elora, lime kilns........ 37
Elridge, George........ 34
Elzevir tp........ 20
Emley process (gypsum)........22, 23
Empire Asbestos Mines Co........ 49
Empire Limestone Co........ 39
Employees. *See* Labour.
Engine sand........ 38
Enniskillen tp.
  Oil 25
  Sand and gravel........ 40
Enterprise, concrete products........ 34
Ernestown tp. *See* Odessa.
Esquesing tp. *See* Milton.
Essex, concrete products........31, 35
Essex co.
  Sand and gravel. *See* Mersea tp.
  Limestone. *See* Amherstburg.
Eureka Flint and Spar Co........21, 27, 49
Exchange premium........ 6
Exeter 28, 34
Exeter Salt Works Co........ 28

—F—

Farmer, W. J........ 42
Farr limestone quarry........ 42
Faulds, Morley........ 39
Federal Feldspar, Ltd........ 21
Feldspar.
  Industry and statistics........2, 3, 20, 21
Feldspar Glass, Ltd........ 48
Feldspar Milling Co........ 20
Feldspar Quarries, Ltd........ 21
Feldspars, Ltd........ 21
Fergus.
  Concrete products........ 34
  Limestone quarry........ 42

Page
Findley, granite quarry........ 42
Fitzroy tp., sand and gravel 39
Flamborough West tp. *See* Dundas.
Fletcher and Son, J. H........ 34
Flieler, Edward........ 37
Flowers, Wm. T........ 34
Fluorspar.
  Statistics and shippers........2, 3, 22
Fonthill 39
Fonthill Gravel Co........ 39
Forbear Sand and Gravel Co........ 39
Ford 35
Forest Reserve permits........ 45
Forrester Falls, brick and tile........ 32
Fort Norman Oil Co........ 48
Fort William.
  Brick 31, 32
  Limestone quarry........ 42
Fort William Brick and Tile Co........ 31
Foster, R. R........ 39
Foster Cobalt Mining Co........ 13
Foster Pottery Co........ 29
Fox, Geo. J........ 31
Foxboro, tile........ 31
Fraser & Leith........ 31
Frid Bros........31, 39
Frid Company, George........ 31
Fritz, Madeleine........ vi
Frontenac co.
  See also Feldspar: Palmerston tp.
  Limestone 42, 43
  Quartz. *See* Portland tp.
  Sand and gravel. *See* Kingston tp.
Frontier silver mine........ 8
Frood nickel mine........ 15
Fuel. *See* Peat fuel: Petroleum.
Fulton, John........ 35

—G—

Galetta 19
Gallagher Lime and Stone Co........ 37
Galt, concrete products........ 35
  Limestone quarry and kilns........37, 43
Gananoque, limestone quarry........ 42
Gardiner, William........ 31
Gardner Feldspar Co........ 21
Garnet and Sons, Thomas........ 35
Garson nickel mine........ 15
Gas, natural.
  See also Natural gas.
  Tax and licenses, revenue........ 46
Gasoline production........ 26
Gauthier, G. H........ 44
Gauthier tp........ 43
  See also Argonaut Gold, Ltd.
General Petroleum and Gas Co........ 48
Gibson, Thomas W........vi, 53
Gillespie, Geo. H. and Co........28, 29
Gillis, Alfred........ 35
Ginn, H. Geo........ 44
Glass sand........ 38
Gleason Coal Co., F. D........ 41
Glenannan, brick and tile........ 31
Glenelg tp., lime kilns........ 37
Gloucester tp.
  Limestone quarrying........42, 43
  Sand and gravel........39, 40
Goderich 28
Goderich Salt Co........ 28
Godfrey & Co., Thomas........ 31

Page
Godson Contracting Co. 39
Gold.
  See also Mining Divisions.
  Nickel-copper mg., production from 15
  Notes and statistics 1-6
  Profit tax, revenue from 47
Gold Nugget Mining and Development Co. 48
Golden Lake, lime kilns 37
Goldwyn Mines, Ltd. 48
Goodwin, W. L. vi
Gordon, C. H. 55
Gorrie, concrete products 35
Goudreau Gold Mines, Ltd. 44
Gowganda Mining Division.
  Recorder's comments 44, 45
Gowganda silver area 9, 11
Graham, John 61
Granite.
  Production and operators 42, 43
Granite Concrete Block Co. 35
Grantham tp. 38
Graphite.
  Industry and Statistics 2, 3, 22
Grasselli Chemical Co. 23
Grattan tp. *See* Caldwell.
Gravel.
  See also Sand and Gravel.
  Definition of, by Highways Dept. 53
  St. Clair river, report by Bartlett 53-61
  Statistics 2, 3, 38, 41
Great Lakes.
  Sand and gravel, revenue from 41
Great Lakes Oil Co. 26
Great Lakes Transportation Co. 41
Green, George 24
Greenock, brick and tile 30
Grenville Crushed Rock Co. 48
Grey co.
  Limestone. *See* Owen Sound.
Grigg, William 31
Grimsby North tp., limestone 43
Guelph.
  Concrete products 34, 35
  Gravel and sand 39
  Lime kilns 37
Guelph tp., limestone quarry 42
Gypsum.
  Industry and statistics 3, 4, 22, 23

—H—

Haanel, B. F. vi
Hadley Co., The C. & J. 41
Hagersville, limestone quarry 42
Haldimand co.
  Gypsum, gravel and sand. *See* Oneida and Seneca tps.
  Limestone quarrying 42, 43
Haliburton 42
Halite. *See* Salt.
Hall and Tampling 35
Hallatt, Wm. 31
Hallatt and Son, H. 31
Halton co.
  Limestone quarrying. *See* Milton.
Halton Brick Co. 31
Hamilton.
  Blast furnace 18
  Brick 30-32

Page
  Concrete products 34
  Limestone quarrying 42, 43
  Sand pits 38, 40
  Sewer-pipe and pottery 29
Hamilton and Toronto Sewer Pipe Co. 29
Hamilton-Bothwell Oil Co. 49
Hamilton Pressed Brick Co. 31
Hamilton Sand and Gravel, Ltd. 39
Hanover, cement plant 33
Hanover Portland Cement Co. 33
Hare, John 35
Harkness, R. B. .... vi, 4
Harriston, tile 31
Harvey, E., Ltd. 37
Harwich tp., sand and gravel 39
Hastings co.
  See also Actlinolite, Feldspar, Huntingdon and Madoc tps.
  Limestone. *See* Marmora tp.
  Sand, gravel and cement. *See* Thurlow tp.
Heavy spar. *See* Barite.
Helon iron pyrites mine 23
Hematite 17
Henderson Farmers' Lime, Ltd. 43
Henderson Mines, Ltd. 28, 29
Hensall, concrete products 35, 36
Hermo Mining Co. 48
Herschel tp., dolomite 29
Hespeler, lime kilns 37
Hewitt & Son, A. B. 35
Higginson, Geo. and Son 43
Highways Dept.
  Sand and gravel pits 40
  See also Dept. of Highways.
Hildreth, Charles 43
Hill, Aaron 31
Hill, A. W. 31
Hill Brick Co. 31
Hinde Bros. 31
Hircock Bros. & Co. 31
Hitch, Mrs. Susan 31
Hitch, Thos. 31
Hoffman, James 39
Holland, H. E. 44
Holland and Son, William 31
Holland Centre 36
Hollinger gold mine 43
Hollinger Consolidated Gold Mines, Ltd. 5, 7, 47
Hollinger Gold Mines, Ltd. 7
Hologden Mines, Ltd. 48
Holtyrex Gold Mines, Ltd. 48
Homegardner Sand Co. 41
Hope tp., sand and gravel 40
Hopkins, P. E. vi
Horne, William 43
Howard tp., sand and gravel 39
Howlett, Fred 31
Hudson Bay Mines, Ltd. 9, 13
Humber Bay, brick 32
Humberstone tp.
  See also Port Colborne.
  Sand and gravel 39
Hunt & Sons, J. W. 35
Huntingdon tp., fluorspar 22
Huntsville Brick Co. 31
Hutchison, R. H. vi
Hutton tp. 17

PAGE

Hydrated lime, statistics........... 37
Hydro-electric power...............1, 4
Hydro-electric Power Commission..39, 43
Hyndman, Jno..................... 35

—I—

Illuminating oil, production......... 26
Imperial Oil, Ltd.................. 26
Incorporated companies.............47-49
Independent Concrete Pipe Co....... 35
Indian Chutes..................... 43
Indian Peninsula Mining Co......... 49
Industrial Minerals Corp........... 21
Industry, mineral. *See* Mineral industry.
Ingersoll, brick and tile............ 32
Inglewood, brick................... 32
Ingrouille, Stephen................. 35
International Feldspar Co.......... 21
International Nickel Co.........15, 17, 27
International Oil Gas Development Co. 48
International Sand and Gravel Co... 41
Interprovincial Brick Co............ 31
Iridium 16, 17
Iron and Iron Ore statistics.....2, 4, 17-19
Iron Pyrites.
  Industry and statistics...........2, 23
Iroquois Sand and Gravel Co....... 39
Islet Exploration Co............... 48

—J—

Jackson Bros...................... 31
Jackson Development Co............ 48
Jacques, Ulderic................... 35
James tp., silver.................. 8
Jamieson, J. M.................... 37
Jamieson Lime Co...............31, 37
Janes, D. A....................... 31
Jasper Brick and Tile Co........... 31
Jeffrey, Leon...................... 31
Jervis & Son, John................. 31
Johnson, James (Sr.).............. 31
Joint Peat Committee............. 25

—K—

Kaladar tp., actinolite.............. 20
Keele, Joseph...................... vi
Keeley silver mine................. 8
Keeley Silver Mines, Ltd........... 9
Kelly Island Lime and Transport Co. 41
Kelso, lime kilns................... 37
Kenilworth 34
Kenora dist.
  Iron pyrites...................... 23
  Limestone. *See* Butler.
  Mining lands leased and sold...... 46
  Soapstone 28
Kenora Mining Division.
  Revenue and business............44, 45
Kent Co., sand and gravel........... 39
Kent Bros......................... 24
Kerr, Fred......................... 31
Kerr Lake Mining Co............9, 13, 47
Kerwood, tile and brick............31, 32
Kilbourne & Son, Harvey.........35, 39
Kincardine.
  Lime kilns....................... 37
  Salt 28

PAGE

Kingdon Mining, Smelting and Mfg. Co. 19
Kingston.
  Concrete products................ 35
  Limestone 43
  Sand and gravel................. 39
Kingston Cement Products, Ltd..... 35
Kingston and Perth Mining Co....... 24
Kingston Penitentiary quarries..... 43
Kingston Sand and Gravel Co....... 39
Kingsville, brick and tile..........30, 32
Kinzel Bros....................... 35
Kirkland Lake.................... 4-6
Kirkland Lake gold area........... 6
Kirkland Lake Gold Mining Co..... 5
Kirkland Motherlode, Ltd.......... 48
Kitchener.
  Brick and tile.................. 32
  Concrete products............... 35
  Lime kilns...................... 37
K. M. B. Syndicate................ 48
Knight, C. W....................vi, 8
Koebel, Joseph Z.................. 31
Korah tp., sand and gravel......... 41
Kowkash Mining Division.........43-45
Kruse Bros....................... 31
Kuhn, Jenny H.................... 31

—L—

Labey & Son, Geo. A............... 31
Labour.
  Lime industry.................. 37
  Mining, general................ 2
  Nickel-copper refining............ 16
  Oil, salt and talc industry........26-28
Lake Erie, gravel and sand......... 41
Lake Erie Sand Co................ 41
Lake Huron.
  Erosion of W. Shore............. 55
Lake Shore Mines, Ltd.............5, 47
Lakeside Development Co.......... 48
Lally, E.......................... 43
Lambton co.
  See also St. Clair river.
  Gravel and sand................. 40
Lanark co.
  See also Burgess N. tp.
  Limestone. *See* Beckwith tp.
  Quartz quarrying................. 27
Lane, Geo........................ 40
Larder Lake Mining Division.
  Recorder's comments............43-45
La Rose silver mine............... 8
La Rose Mines, Ltd............9, 13, 47
Larter, Chas...................... 40
Lattimore and Campbell............ 42
Law Construction Co............... 43
Lead.
  Industry and statistics....2-4, 10, 12, 19
Leamington 35, 41
Leases, mining. *See* mining leases.
Lebel tp.......................... 43
Lebel Lode, Ltd................... 48
Leeds tp., granite and limestone...42, 43
Lefebvre, Jos..................... 35
Lennox and Addington co.
  See Odessa. Richmond tp.
Lesperence, Peter J................ 35
Levack nickel mine................ 15
Levack tp., limestone quarry........ 43

PAGE

Le Viness & Sons Co. 40
Licensed companies. 47-49
Licenses for gravel and sand. 41
Licenses, miners'. 44, 45
Lime.
  See also Sand-lime brick.
  Statistics and producers. 36, 37
Lime phosphate. *See* Apatite.
Limestone.
  Quarry operators; production. . . . 42, 43
Lincoln co.
  See Grantham tp.; Grimsby N. tp.
Lindsay.
  Brick and tile. 30, 32
  Concrete products. 34
Lindsay, Stephen. 31
Lishman, W. H. 35
Locust Hill. 34
London, brick and tile. 31, 32
  Concrete products. 34, 35
London tp., sand and gravel. 41
Longford Mills. 43
Longford Quarry Co. 43
Lorrain Operating Co. 48
Lorrain, South. *See* South Lorrain.
Loughborough Mining Co. 24
Loughborough tp.
  Feldspar and mica. 21, 24
Louisiana, U.S., sulphur. 23
Lubricating oil, production. 26
Lucknow, concrete products. 35
  Tile 32
Lumsden silver mine. 9
Lyons Fuel and Supply Co. 40
Lythmore, gypsum. 22

—M—

McAlpine, Daniel. 40
McAulay, N. J. 44
McConnell Consolidated Mines, Ltd. 21
McCormick Bros. 31
McDonnell, George. 43
McEnaney Gold Mines, Ltd. 48
McGregor and Gammage. 31
McIntyre gold mine. 43
McIntyre Procupine Mines, Ltd. . 4, 5, 7, 47
McIvor Bros. 31
MacKay Bros. 31
McKinley-Darragh-Savage Mines of
    Cobalt, Ltd. 9, 13
McLaren, W. L. 24
McLenaghan, W. A. 35
McLoughlin, Jno. 31
McMahon, Robert. 31
McMillan, J. G. vi
McNeely, D. R. 43
McNeill, W. K.
  Report by, on Provincial Assay
    Office 49-52
McQueen, Alexander. 35
McVittie tp. 43
Madoc.
  See also Wallbridge iron m.
  Brick 21
  Talc 28
Madoc tp., fluorspar. 22
Magnetite 17
Magpie iron mine. 17
Maisonville Mining Co. 48
Majestic Gold Mines, Ltd. 48

PAGE

Malahide tp., gravel and sand. 49
Malden tp. *See* Amherstburg.
Malloy, Wm. B. 40
Manley-O'Reilly Gold Mines, Ltd. . . . 48
Map.
  St. Clair River, gravel deposits.
    . . . . *facing* 58
Maple Mountain silver area. 11
Maple Sand, Gravel and Brick Co. . . . 40
Marble.
  Production and operators. 42, 43
March tp. feldspar. 21
Markham 35
Markus, Wm., Ltd. 43
Marmora, limestone. 43
Marmora tp. *See* Deloro.
Mars Mines, Ltd. 48
Marshall, James. 37
Martin Estate, David. 31
Martindale gypsum mine. 22
Marty, Emil. 35
Marysville Land Co. 41
Matheson Gold, Ltd. 48
Medonte tp. *See* Coldwater.
Merkley's, Ltd. 32
Merlin, tile. 31
Mersea tp., sand and gravel. 41
Metallic minerals.
  Statistics 2-19
Methuen tp., limestone. 43
Mica, industry and statistics. 2, 3, 23
Mica lake. 24
Michipicoten area. *See* Helen iron
    pyrites m.
Mickle, G. R. 47
Middle channel, St. Clair river. 56
Middlesex co., gravel and sand. 39-41
Middlesex & Dover Oil & Gas Co. 48
Middleton, Charles. 32
Middleton, John N. 43
Middleton tp., sand and gravel. 39
Midland, blast furnace. 18
Midland Iron and Steel Co. 18
Mikado Consolidated Mines, Ltd. . . . 48
Milburn, T. E. 41
Mildmay, concrete products. 35
Millard, David. 40
Mille-Roches 39
Miller, Thos. 35
Miller, W. N. 44
Miller Lake O'Brien silver mine. 47
Millerton Gold Mines, Ltd. 7
Mills, Geo. E. 32
Mills, Jas. 40, 43
Milton, brick. 32
  Limestone 43
Milton Pressed Brick Co. 32
Mimico, brick and tile. 32
  Sewer pipe. 29
Miner, J. T. 32
Mineral industry, 1921.
  Statistical review, by W. R. Rogers 1-52
Mineral water, industry and statis-
    tics 2, 3, 24
Miners' licenses. 44-46
Mining Companies
  List of incorporated and licensed 47-50
Mining Corporation of Canada,
    Ltd. 8, 9, 13, 47

PAGE

Mining Divisions.
  Recorders' comments............43-45
Mining revenue.................... 46
Mining Tax Act, revenue..........46, 47
Mitchell, concrete products.......... 35
Mitchell, Ralph R.................. 35
Molybdenite 3, 4
Mond Nickel Co............16, 17, 27, 43
Monel metal......................... 15
Monmouth tp., feldspar............ 21
Mono Petroleum Products, Ltd....... 43
Monteagle tp., feldspar............. 21
Montreal River Mining Div.
  Recorder's report................44, 45
Montreal River silver area.......... 11
Montreal Kirkland Mines, Ltd....... 48
Moore tp., gravel..................57, 59
  Oil 25
Moorefield 35
Moose Mountain, Ltd................ 17
Morgan, J. W....................... 44
Morgan, M. R....................... 44
Morrison Bros...................... 43
Morse, W. O........................ 35
Mosa tp., oil....................... 25
Mosure, F. B........................ 9
Moulding sand...................... 38
Moulton tp. *See* Dunnville.
Mount Brydges, brick and tile....... 31
Mount Dennis, brick................ 32
Mount Eagle Feldspar Co.......... 48
Mount Forest, concrete products..... 35
Moyer, Lovelace Co................. 40
Muir Porcupine Gold Mg. Co........ 48
Murphy, Thomas.................... 44
Murray nickel mine................. 15
Murray tp.......................... 38
Muskoka dist., limestone. *See* Draper tp.
Muskoka Quarries, Ltd.............. 43

—N—

Napanee.
  Brick and tile.................. 30
  Lime kilns...................... 37
  Limestone quarry..............42, 43
Naphtha production................ 26
Nassagaweya tp., lime kilns........ 37
National Sand and Material Co..... 41
Natural gas.
  Industry and statistics......2, 3, 24, 25
Neelon tp., quartz quarrying....... 27
Nelles, limestone quarry........... 42
Nepean tp., limestone. *See* Ottawa.
New, Edward...................... 32
Niagara river, gravel and sand...... 41
Niagara Falls.
  Concrete products............... 35
  Graphite, artificial.............. 22
  Lime kilns...................... 37
Niagara Sand Corporation.......... 41
Nichol tp., limestone.............. 42
Nichols Chemical Co............... 23
Nickel.
  See also Copper.
  Mining and smelting............ 17
  Statistics and industry.......1-4, 15-17
Night Hawk Peninsular gold mine... 43
Nipissing dist.
  Mining lands leased and sold...... 43
Nipissing silver mine.............. 8, 9
Nipissing Mining Co., Ltd.......... 14
Non-metallic minerals, statistics...2, 3, 19
Norfolk co.
  Limestone. *See* Woodhouse tp.
  Sand and gravel. *See* Middleton tp.
Norman, Horace F.................. 35
North channel, St. Clair river..56, 57, 60
North American Feldspar, Ltd....... 21
North Bay, brick.................. 32
Northcrown Porcupine Mines, Ltd... 5
Northern Canada Power Co.......... 4
Northpines 23
North Trail Gold Mines, Ltd........ 48
Northumberland co. *See* Murray tp. Seymour tp.
Norton, Alsey..................... 32
Norwich, brick and tile............ 48
Noyes Mining Co.................. 48

—O—

Oakes, Sam........................ 35
Oakland tp........................ 40
Oakland Sand and Gravel Co....... 40
O'Brien silver mine................ 8, 9
O'Brien and Fowler................ 21
O'Brien, M. J., Ltd................9, 47
O'Dell, Albert..................... 32
O'Dell, Henry..................... 32
Odessa, limestone................. 43
O'Donohue, Michael............... 37
O'Flaherty, T. F.................. 44
Ogden tp......................... 43
Oil. *See* Petroleum.
Oil Springs......................25, 35
Oil Springs Tile and Cement Co.... 35
Ojibway, blast furnaces............ 18
Ollmann Bros....................32, 40
Omemee, concrete products......... 36
Oneida tp.
  Gypsum 22
  Limestone. *See* Hagersville.
  Sand and gravel................ 39
Onondaga tp., oil................. 25
Ontario co. *See* Brock tp., Langford Mills.
Ontario Brick and Tile Plant....... 32
Ontario Dolomite Manufacturing Co. 20
Ontario Gypsum Co................ 22
Ontario Highways Dept............ 40
Ontario-Kirkland gold mine......... 4
Ontario Paving Brick Co........... 32
Ontario People's Salt and Soda Co... 28
Ontario Rock Co.................. 23
Ontario Sewer Pipe and Clay Products, Ltd..................... 29
Ontario Smelters and Refiners, Ltd. 11
Ontario Stone Corporation......... 43
Ophir silver mine.................. 9
Ord, John A...................... 35
O'Reilly, T. E.................... 32
Orillia North tp., limestone........ 43
Orser and Wilson.................. 21
Orser-Kraft Feldspar, Ltd.......... 21
Osgoode tp., limestone............ 42
Osmium 16
Ottawa.
  Brick 32

Page
  Limestone 42, 43
  Sand and gravel 39
Ottawa Brick Manufacturing Co. 32
Ottawa Improvement Commission 43
Ott Brick and Tile Manufacturing Co. 32
Owen Sound.
  Brick 32
  Concrete products 35
  Lime kilns 37
  Limestone quarry 43
Owen Sound Brick Co. 32
Oxford co., sand and gravel. *See* Dereham tp.
Oxford East tp., limestone. *See* Woodstock.

—P—

Page, George Leslie 35
Pakenham, concrete products 35
Paisley, brick 32
Palatine Mining Co. 17
Palladium 16
Palm, Jacob 35
Palmerston tp., calcite 20
Paraffin wax, production 26
Parkhill, brick and tile 30
Parks, W. A. vi
Parks Bros. 37
Paris Sand and Gravel Co. 40
Parry Sound, blast furnace 18
Parry Sound Iron Co. 18
Parry Sound Mining Division 44
Pearce Co. 43
Pears and Son, James 32
Peat fuel 23, 25
Pebbles of St. Clair river gravel 57, 58
Peel co. *See* Caledon tp.; Chinguacousay tp.
Peerless Artificial Stone Co. 35
Pelham tp. 39, 40
Pembroke, brick 31
  Limestone 43
Pembroke Brick Co. 32
Penn-Canadian Mines, Ltd. 9, 14
Pennsylvania Smelting Co. 12
People's silver mine 9
Perkins, George A. 43
Permits, building 20
  Mining (prospecting) 44-46
Perth, sandstone quarry 43
Perth co.
  Limestone 43
  Sand and gravel 40
Perth Amboy, N.J. 12
Peterborough.
  Brick and tile 30
  Concrete products 36
  Sand and gravel 40
Peterborough co.
  See also Peterborough, Smith tp.
  Limestone quarries 43
Peterson Lake Silver-Cobalt Mining Co. 14
Petrol Oil and Gas Co. 49
Petroleum statistics 2, 3, 25, 26
Petrolia, brick and tile 31
  Oil 25, 26
Pfaff, Wm. E. 35
Phillips and Son, Thos. 32

Page
Phinn Bros. 32
Phippen and Field 32
Phosphate of lime. *See* Apatite.
Pickins feldspar mine 21
Pig iron 18
Piggott and Co., Geo. 32
Pigments, dolomite for 20
Pilon, A. 5
Pipe, drain. *See* Drain pipe or tile.
Pipe, sewer. *See* Sewer pipe.
Pit operators. *See* Sand and gravel.
Plaster of Paris. *See* Gypsum.
Platinum 16, 17
Platinum metals.
  Industry and statistics 2-4, 15-17
Plaxton and Bray 32
Plympton tp., oil 25
Point Anne Quarries, Ltd. 43
Ponsford, A. E. 40
Porcupine, gold 4-6
Porcupine gold area.
  Production; dividends 6
Porcupine Mining Division.
  Recorder's comments 43, 45
Porcupine Crown Mines, Ltd. 7
Porcupine Davidson Gold Mines, Ltd. 48
Porcupine Peninsular Gold Mines, Ltd. 48
Port Albert, concrete products 36
Port Arthur 17, 18
Port Arthur Mining Division.
  Revenue and business 43, 45
Port Colborne.
  Blast furnace 18
  Cement plant 33
  Nickel refinery 15
Port Credit Brick Co. 32
Porter, Thompson 40
Porter Gold Mines, Ltd. 48
Port Hope, concrete products 35
Portland Cement. *See* Cement.
Portland tp.
  Feldspar 21
  Quartz 27
Port Rowan, brick and tile 30
Portsmouth 43
Post, W. J. 9
Pottery.
  Industry and statistics 2, 3, 30-32
Precious-metals cement 17
Prescott Co., peat. *See* Alfred.
Pressed brick. *See* Brick.
Preston, concrete products 35
Price, Jno., Ltd. 32
Price and Cumming 32
Price and Smith 32
Princeton, concrete products 35
Prior, Elston M. 40
Prisons and Asylum Branch, Dept. of Provincial Secty. 42
Production, mineral 2-29
Profit Tax, revenue 46, 47
Proton, brick and tile 32
Provincial Assay Office. *See* Assay Office.
Provincial Feldspar Co. 21
Pueblo, Col. 12
Puslinch, lime kilns 37
Pyrites. *See* Iron pyrites.

PAGE

—Q—

Quarries P. O., Russell co. 42
Quarry operators 42-43
Quartz (silica).
  Industry and statistics 2, 3, 27, 28
Queen Lebel Gold Mines, Ltd. 48
Queenston Quarries, Ltd. 48
Quick, Charles R. 40
Quicklime statistics 37
Quigley, B. C. 40

—R—

Raglan tp., corundum 20
Railway ballast 38
Rainham tp., limestone. *See* Nelles
Rainy River dist.
  Mining lands sold and leased 43
Raleigh tp.
  Oil 25
  Sand and gravel 39
Rama tp., limestone. *See* Longford Mills.
Rea Consolidated Gold Mines, Ltd. 7
Recorders' reports 43-45
Redden, Henry 40
Refineries, petroleum 26
  Silver-cobalt 11, 12
Regent Mines, Ltd. 9
Reid, C. F. 43
Reid, Fraser D. vii
Reid, M. P. 35
Reinecke, L. 54
Rendix Mines, Ltd. 48
Renfrew, brick and tile 31
Renfrew co.
  See also Brougham tp.; Caldwell; Renfrew; Raglan tp.
  Lime kilns 37
  Limestone. *See* Pembroke.
Rhodium 16-17
Ribble Mines, Ltd. 48
Richards, M. 5
Richardson and Son, James 32
Richmond tp., sand and gravel 40
Rickard tp., sand and gravel 41
Rideau Canal Supply Co. 40, 43
Ridgetown, brick and tile 31
Ridgeville, concrete products 34
Ridgeway, concrete products 36
Right-of-Way Mines, Ltd. 14
Right-of-Way Mining Co. 14
Rivers.
  Gravel and sand from, revenue 41
Roads.
  Gravel for, composition 53
Robertson Co., D. 37, 43
Robidoux, H. L. 35
Robillard, H. and Son 43
Robinson, Ed. 35
Rock Products Co. 21
Rockwood, lime kilns 37
Roddy and Monk 43
Rogers, F. & Co. 43
Rogers, W. R. vi
  Statistical Review by, of Mining Industry 1-52
Rollins, D. W. 32
Ross and Son, Charles 35
Ross tp., lime kilns 37
Royal-Flush Oil and Gas Co. 48

PAGE

Ruscomb, brick and tile 31
Russell co., limestone. *See* Quarries P. O.
Russell island 60
Russelo, Howard 35
Ruthenium 16

—S—

St. Anthony Gold Mines, Ltd. 48
St. Anthony Mines Syndicate 5
St. Catharines.
  Brick 32
  Concrete products 35
St. Clair river.
  Gravel deposits 41
  Report by Bartlett 53-61
St. Clair lake 55
St. Clements, tile 31
St. Marys cement 33
  Limestone 43
St. Marys Cement Co. 33
St. Onge, H. 35
St. Thomas, brick and tile 3, 31
Salt.
  Industry and statistics 3, 27, 28
Saltfleet tp. 40, 43
Sand and Gravel.
  Operators 38-41
  Royalty and rental 46
  See also St. Clair river.
Sand-lime brick 38
Sand and Supplies, Ltd. 40
Sanderson-Kirkland Gold Mines, Ltd. 48
Sandstone quarries 42, 43
Sandwich, concrete products 35
  Salt 28
Sarjeant Co. 40
Sarnia.
  Concrete products 34
  Gravel 56, 59
  Oil refinery 26
  Salt 28
Sarnia tp., oil 25
Sault Ste. Marie.
  Blast furnaces 18
  Brick 31
Sault Ste. Marie Mining Division.
  Recorder's comments 44, 45
Scarboro 38
Scarborough tp. 38, 39
Schmidt, J. T. 35
Schram, A. J. 35
Scott, F. S. 40
Seaforth, brick and tile 31, 32
Seneca tp., gypsum 22
Seneca-Superior silver mines 14
Sewer pipe statistics 2, 3, 29-32
Seymour tp. *See* Campbellford.
Shale Products, Ltd. 32
Shannon, Hiram L. 40
Shaw Oil and Development Co. 48
Sherbrooke South tp.
  Feldspar and quartz 21, 27
Sherkston 39
Shirk, Geo. M. 40
Shoemaker, Allen 35
Showel Bros. 35
Siderite 17
Silica brick 27

PAGE
Silver.
  Mining 8-14
  Profit Tax 47
  Sault Ste. Marie Mining Division .. 44
  Statistics 2, 10-14
  See also Cobalt.
Silver Leaf silver mine 8
Silver Queen silver mine 9
Simcoe co.
  Limestone, gravel and sand 40, 43
Skinner, Robt. 40
Sleeman, P. 40
Smith, Albert 35
Smith, Allan G. C. 35
Smith Estate 40
Smith, John S. 37
Smith tp., sand and gravel 39, 40
Smiths Falls Malleable Castings Co. 49
Smithson, Frank 35
Smithville 43
Snelgrove, A. 32
Soapstone. *See* Talc.
Soda ash 27
Sombra tp., gravel 57, 59
Somerville tp., limestone 42
Somerville and Son, W. G. 34
South channel, St. Clair river 56
South Keora Mines, Ltd. 48
South Lorrain silver area 8-14
Southwold tp., sand and gravel 39
  Tile 32
Spar. *See* Feldspar.
Spar, heavy. *See* Barite.
Sproat, Wm. M. 32
Stag island 59
Stamford 39
Stamford tp. 41
  See also Niagara Falls.
  Sand and gravel 38-41
Standard Brick Co. 32
Standard Iron Co. 18
Standard White Lime Co. 37, 43
Stanley, J. 34
Stanley Corners 36
Statistics. *See* Rogers, W. R.
Steel Company of Canada 18
Stinson, R. H. 36
Stroh, M. C. 32
Stone.
  Industry and statistics 2-4, 42, 43
Stoness, S. M. 24
Stormont co. *See* Milles-Roches.
Storrington 21
Storrington Feldspar Co. 21
Stothart, James 40
Stratford, brick and tile 30
Strathroy, concrete products 35
Streets and O'Brien 43
Structural materials.
  Industry and statistics 29-43
Sturgeon Falls 43
Sturgeon Lake, gold 5
Sudbury 34
Sudbury dist.
  Iron. *See* Moose Mountain, Ltd.
  Limestone 43
  Mining lands sold and leased 46
  Nickel. *See* Nickel.
  Quartz quarrying 27

PAGE
Sudbury Mining Division.
  Recorder's comments 43, 45
Sulley, W. J. 40
Sulphide, Ont. 23
Sulphur ore. *See* Iron Pyrites.
Superior Sand and Gravel Co. 41
Superior Tile Co. 32
Sutherland, T. F. vi
Swansea 29, 31, 38
Sydenham tp. *See* Owen Sound.
Sydenham Block and Tile Co. 36
Sydenham-St. Vincent Oil and Gas Co. 48

—T—

Talc.
  Industry and statistics 2, 3, 28, 29
Tapestry brick. *See* Brick.
Tar 26
Tarentorus tp., sand and gravel 41
Taxes. *See* Revenue; Mining Tax.
Taylor and Hall 36
Teas, L. P. 54
Teck tp. 43
Teck-Hughes Gold Mines, Ltd. 5, 7, 47
Teeswater, lime kilns 37
Telford, John C. 32
Telford, Peter 36
Temiskaming and Hudson Bay Mining Co. 17
Temiskaming Mining Co. 14
Terra Cotta, P. O. 31
Texas, sulphur 23
Thames river 41
Thames Quarry Co. 43
Thamesville, oil 25
  Tile 31
Theaker, Wm. 36
Thedford, tile 31
Thorndale, tile 31
Thorold.
  Limestone quarry 43
  Refinery 11
Thunder bay 41
Thunder Bay dist.
  Limestone. *See* Fort William.
  Mining lands sold and leased 46
Thurlow tp.
  Cement plants 33
  Sand and gravel 40
Tigert, Jno. 26
Tilbury brick and tile 32
Tilbury, oil field 25
Tile.
  Industry and statistics 2, 3, 30-34
Tillsonburg, concrete products 36
Timiskaming dist.
  Gold and silver 4-14
  Limestone quarry 42
  Mining lands leased and sold 46
Timiskaming Mining Division.
  Recorder's comments 44, 45
Timmins Graphite Mines 22
Tiny tp., sand and gravel. *See* Penetang.
Tolson, Mrs. Margaret J. 32
Tope Estate 32
Toronto.
  Brick and tile 30-32, 38
  Concrete products 34

PAGE
  Feldspar. *See* Feldspar.
  Limestone ... 42
  Petroleum refinery ... 26
  Pottery works ... 30-32
Toronto Brick Co. ... 32, 37
Toronto-Grey Gas and Oil Co. ... 49
Toronto Lime Co. ... 37
Toronto Plaster Co. ... 37
Tough-Oakes Gold Mines, Ltd. ... 7
Townsite-City silver mine ... 9
Trap.
  Production and operators ... 42, 43
Trethewey silver mine ... 9
Trethewey Silver Cobalt Mines, Ltd. ... 9, 14
Triplex Gold Mines, Ltd. ... 49
Trousdale, James ... 24
Turner and Co., C. B. ... 32
Tweed ... 20
Two-in-One Gold Mines, Ltd. ... 49

—U—

United Fuel and Supply Co. ... 41, 61
United States Metal Refining Co. ... 12
Usborne tp., sand and gravel ... 40

—V—

Vaughan tp., sand and gravel ... 39, 40
Vermilion lake, Kenora dist. ... 23
Verona Mining Co. ... 21
Victoria co., limestone. *See* Eldon.
Victoria nickel mine ... 15
Vienna, brick and tile ... 31
Vogan, Samuel ... 37

—W—

Wabigoon, soapstone ... 28
Wages. *See* Labour.
Wagstaff, Charles ... 32
Wagstaff & Co., A. H. ... 32
Waide, J. C. ... 32
Waite, John E. ... 32
Walker Bros. ... 43
Wall plaster. *See* Gypsum.
Wallace and Sons, R. ... 32, 43
Wallaceburg.
  Concrete products ... 36
  Lime kilns ... 37
  Petroleum refinery ... 26
  Tile ... 31
Wallbridge iron mine ... 17
Walpole tp., limestone ... 42
Wanapitei lake ... 43
Warwick, salt ... 28
Warwick Brick Works, Ltd. ... 32
Waterloo.
  Brick ... 30
  Concrete products ... 35
Waterloo co., sand and gravel ... 39, 40
Waterpower ... 4, 43
Waters, mineral. *See* Mineral Waters.
Watford, brick and tile ... 31
Watts, Alfred ... 36
Webber, John ... 43
Webster, A. R. ... vi
Webster, Jas. S. ... 43
Welland, concrete products ... 36
Welland co.
  See also Niagara Falls; Port Colborne.

PAGE
  Limestone. *See* Bertie tp.; Thorold tp.
  Sand and gravel ... 38, 39
Wellington co., limestone ... 42
  Sand ... 40
Wentworth co.
  See also Barton tp., Hamilton, Saltfleet tp.
  Limestone quarry ... 42
Wentworth Oil and Gas Co. ... 49
Wentworth Quarry Co. ... 43
Weppler, Henry ... 37
West Beaumont Gold Mines, Ltd. ... 49
Western Canada Flour Mills Co. ... 28
Western Salt Co. ... 28
West Lorne, concrete products ... 35
Westminster ... 40
Westminster tp. ... 39
West Toronto ... 38
Wettlaufer Lorrain Silver Mines, Ltd. 14
Wheatley, concrete products ... 36
Wheeling Feldspar Co. ... 49
Whitby Brick and Clay Products Co. ... 32
Whitchurch tp., sand and gravel ... 38, 40
White, Sydney ... 36
White & Co., Homer ... 41
Whiteley, Thos. W. ... 61
Whitevale, concrete products ... 34
Whitlock, Peter ... 36
Whitney tp. *See* Porcupine.
Wiarton, lime kilns ... 37
Williams, E. J. ... 36
Willox, Henry ... 41
Wilson, Geo. S. ... 32
Wilson, Samuel and Sons ... 32
Winch Bros. ... 32
Winchester Cement Block and Tile Mfg. Co. ... 36
Windsor, concrete products ... 34, 35
  Salt ... 28
Windsor Brick and Tile Co. ... 32
Windsor, Essex and Lake Shore Ry. Co. ... 41
Windsor Salt Works, Ltd. ... 28
Windsor Sand and Gravel Co. ... 41
Wolfe Island tp., limestone ... 43
Woodhouse tp., limestone ... 42
Woodslee Brick and Tile Co. ... 32
Woodstock, concrete products ... 35
  Limestone ... 43
Woodtick island ... 59
Worthington nickel mine ... 15
Wright, Douglas G. H. ... vi
Wright, J. C. ... 32
Wright and Co. ... 41
Wright and Sons, Geo. ... 32
Wright-Hargreaves Mines, Ltd. ... 4-7
Wyoming, tile ... 32

—Y—

Yack, Henry ... 41
Yarmouth tp., sand and gravel ... 39-41
York co.
  See Scarborough tp., Swansea, Toronto, Vaughan tp. and West Toronto.
York tp. ... 38
Young and Son, John ... 36

—Z—

Zinc production ... 4
Zurich, brick and tile ... 31

PROVINCE OF ONTARIO
DEPARTMENT OF MINES

HON. CHARLES MCCREA, MINISTER OF MINES THOS. W. GIBSON, DEPUTY MINISTER

THIRTY-FIRST ANNUAL REPORT
OF THE
ONTARIO DEPARTMENT OF MINES
BEING
VOL. XXXI, PART II, 1922

Geology of the Mine Workings of
Cobalt and South Lorrain Silver Areas
By
Cyril W. Knight

Together with a Description of
Milling and Metallurgical Practice in Treatment of Silver Ores at Cobalt
By
Fraser D. Reid, James J. Denny and R. H. Hutchison

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY OF ONTARIO

TORONTO
Printed and Published by Clarkson W. James, Printer to the King's Most Excellent Majesty
1924

PRODUCED BY
The
United Press
LIMITED
TORONTO
CANADA

TABLE OF CONTENTS

PAGE
AUTHOR'S PREFACE xi
OUTLINE OF THE REPORT xiii

CHAPTER I.—INTRODUCTION 1-41
  Area Covered by Report 3
  When Work Was Done 3
  Preliminary Report 3
  Maps Accompanying Report 3
 The Ores and How They Occur 5
   Grade of Ore 5
   Depth of Ore Shoots 5
   Why the Silver Disappears When Veins Pass from Cobalt Series into Keewatin 5
   Relative Quantities of Silver in the Several Rock Series 7
   Ninety Per Cent. of Silver from "Lower Contact" 7
   Why More Veins in the Cobalt Series than in the Other Rocks 8
  Factors Governing Formation of Silver Ore-Shoots 8
  Veins in Cobalt Series above Depressions in Keewatin 11
  Faults 12
   Lake Timiskaming Fault 15
  Relation of Faults to Veins 16
  Character of Vein-Filling in Faults 17
  Influence of "Iron Formation" and Lamprophyre Dikes in Formation of Vein Fractures 18
  Ore Reserves and Sampling 18
   Total Shipments of Silver from Entire Cobalt Area, 1904-1923 18
   Table Showing Silver Production in 1911 19
  Dividends and Bonuses Paid by Silver Mining Companies to December 31st, 1922 20
 Government Revenue and Silver Production 22
   Table Showing Royalties Received by the Ontario Government 22
   Silver Production from the Cobalt Area Proper—Troy Ounces Shipped 23
   Shipments from Gowganda Mines, 1910-1922 28
  Silver Production from Important Localities in the World Compared 29
   World's Average Annual Production of Silver, 1493-1912 29
   World's Annual Production of Silver, 1901-1921 29
   Yearly Average Price of Silver, 1895-1923, New York 29
 General Geology 30
   Legend 30
  Structure of the Rocks 31
  Folding 32
  The Kerr Lake Diabase Dome 32
  Thickness of Nipissing Diabase Sill 34
  Sill Probably Intruded from Southeast 34
  Keewatin "Iron Formation" 34
  Minerals Occurring in the Veins 35
   Epsomite ($MgSO_4+7\ H_2O$) 36
  Origin of Ores—Primary Character of Native Silver 36
  Secondary Silver 39
  Surface Geology 40
   Keewatin Lava Flows 40
  Correspondence Regarding Re-Survey of the Cobalt Silver Area 41

CHAPTER II.—GEOLOGY OF THE MINE WORKINGS 43-187
 Nipissing 44
  Costs 44
  Development in Year 1922 45
  Veins 45
  Ore Reserves 45
  Nipissing Mine Workings 46
   Mine Workings North of Cobalt Lake 46
   Workings on Vein No. 64 49
   Meyer Vein System, and Veins 544, 490, 80, and 100 52
   Nipissing Mine Workings South of Cobalt Lake 57
   Nipissing Mine Workings from Shaft No. 63 60
   Vein No. 28 Tunnel 62

PAGE

Mining Corporation.......... 63
  Ore Reserves.......... 64
  Structure.......... 64
  Veins.......... 65
Buffalo.......... 66
  Veins.......... 66
  Faults.......... 67
  Relation of Veins to Faults.......... 69
  Buffalo Mine Workings.......... 69
City of Cobalt.......... 70
  South End of City of Cobalt.......... 71
  North End of City of Cobalt.......... 73
Cobalt Lake.......... 74
    Width and Grade of Veins, Cobalt Lake Fault.......... 75
  Cobalt Lake Mine Workings.......... 76
  Townsite Extension.......... 78
  Townsite.......... 78
    Workings from No. 1 Shaft, Townsite.......... 79
    Faults.......... 80
    Structure of the Rocks.......... 80
    Workings from No. 4 Shaft, Townsite.......... 81
Coniagas.......... 82
    The "Contact" Fault.......... 83
  Coniagas Mine Workings.......... 84
Kerr Lake.......... 87
  Kerr Lake Mine Workings from No. 7 Shaft.......... 90
  Kerr Lake Mine Workings from No. 3 Shaft.......... 91
Hargrave (Kerr Lake).......... 92
La Rose Mines.......... 93
  La Rose.......... 93
    Cobalt Lake Fault.......... 93
    Relation of Cobalt Lake Fault to Main La Rose Vein.......... 94
    McDonald and No. 3 Veins.......... 94
    Fault 64.......... 94
  La Rose Extension (La Rose).......... 95
  Violet (La Rose).......... 96
  Princess (La Rose).......... 97
  Lawson (La Rose).......... 99
  University (La Rose).......... 100
  Fisher-Eplett (La Rose).......... 101
Crown Reserve.......... 101
    Average Cost of Producing Silver to the End of Year 1919, Crown Reserve... 102
    Mill and Smelter Returns to End of 1919, Crown Reserve.......... 102
  Development.......... 104
    Total Mine Development, Crown Reserve.......... 104
  Structure.......... 104
    Thickness of Cobalt Series, Crown Reserve.......... 105
  Veins.......... 105
    Silver Production of Veins, Crown Reserve, to End of Year 1919.......... 105
  Pumping of Water out of Kerr Lake.......... 107
  Deep Diamond-Drilling at Crown Reserve.......... 107
    Analysis of Quartz-Gabbro, Crown Reserve.......... 109
  Description of Mine Workings.......... 109
McKinley-Darragh-Savage.......... 113
    Cost of Producing Silver at McKinley-Darragh in year 1922.......... 113
    Costs and Profits Per Ounce of Silver Recovered, McKinley-Darragh.......... 114
    Extent of Mining Operations, McKinley-Darragh Mines.......... 114
    Ounces of Silver Shipped from the McKinley-Darragh Mines, 1906 to 1922... 115
  Description of McKinley-Darragh Workings.......... 117
Savage.......... 120
O'Brien.......... 121
  Description of O'Brien Mine Workings.......... 123
Temiskaming.......... 128
  Structure.......... 129
  Veins.......... 130
  Copper.......... 132
  Special Examinations.......... 132
  The Discovery of the Temiskaming Mine, by Charles A. Richardson.......... 134
  The Early History of the Temiskaming Mine, by Norman R. Fisher.......... 135
  Description of Temiskaming Mine Workings.......... 138

PAGE

- Trethewey (Coniagas) 140
  - Trethewey Mine Workings 141
- Hudson Bay 142
  - Hudson Bay Mine Workings 143
- Beaver Consolidated 145
  - Beaver Mine Workings 148
- Seneca-Superior 152
- Penn-Canadian 156
- Drummond (Cobalt Comet) 158
- Right of Way 159
  - Workings North of Cobalt Lake 159
  - Mine Workings South of Cobalt Lake 160
- Silver Queen 161
- Chambers-Ferland (Aladdin) 161
  - Workings from No. 4 Shaft 162
  - Workings from No. 2 Shaft, Right of Way 164
  - Workings North of the Northeast Corner of O'Brien 165
- Foster 165
- Peterson Lake 167
- Silver Leaf 167
- Colonial 170
- Drummond Fraction 170
- Bailey 172
- Provincial 172
- Edwards and Wright (Green-Meehan and Red Rock) 174
- Little Nipissing Silver Mine 177
- Mercer 177
- Adanac 177
- Lumsden 178
- Rochester 179
- Ruby 179
- North Cobalt Mine 180
- Genesee 181
- Oxford Cobalt 183
- Victory 184
- Agaunico 185
- Prince 186
- Watash 186
- Ophir and People's Silver 187

CHAPTER III.—SOUTH LORRAIN 189-238

- Introduction 189
  - Production 191
  - Vein Minerals 191
  - Where Veins Occur 193
  - Pre-Glacial Weathering 193
  - Length of Ore-Shoots 193
  - The "Mother Lode" 194
  - Faults 194
  - Discovery of Ore Bodies 195
  - Maps and Plans 196
  - General Geology 196
    - The South Lorrain Diabase Dome 196
    - Details of the South Lorrain Diabase Dome 197
    - The Outside of the Diabase Dome (Top of the Sill) 197
    - The Inside of the Diabase Dome (Bottom of the Sill) 201
- Description of Properties 202
  - Keeley 202
    - Veins and Rock Structures 207
    - Pre-Glacial Weathering 208
    - Secondary Silver 210
    - Description of Keeley Mine Workings 210
      - Workings from No. 3 Shaft, Keeley Mine 210
      - Workings from No. 4 Shaft (Beaver Lake) 217
      - Workings from No. 1 Shaft, Original Discovery, Keeley Mine 218
  - Frontier and Crompton 219
    - Pre-Glacial Weathering 220
    - Early History of Frontier Mine 220
    - Description of Frontier Mine Workings 221
  - Wettlaufer 224
  - Curry Claim, H.R. 105 228

PAGE

- Silver Eagle Claim, H.R. 97 229
- Bellellen Claim, R.L. 470 229
- Maidens Claims, H.R. 69, H.R. 70, H.R. 67, H.R. 66 230
- Little Keeley Claim, H.S. 40 233
- Lorrain Consolidated Claim, H.R. 24 233
- Montrose, H.R. 459 234
- T.C. 71 234
- Taylor Claim, R.L. 471 234
- Alice Lorrain Claim, R.L. 467 234
- Forneri Claim, H.S. 42 234
- Sharp Lake Claim, B.C. 100 235
- H.R. 63 235
- H.R. 14 235
- Tallen Claim, H.R. 106 235
- King George Claims, H.R. 110, H.R. 170 236
- T.C. 73 236
- Toronto Lorrain Claim, H.S. 308 236
- H.S. 500 236
- H.R. 56 236
- Lang-Caswell 237
- Giroux 237
- Lorrain Trout Lake Mines Claim, H.R. 103 238

CHAPTER IV.—MINING AND METALLURGICAL PRACTICE IN TREATMENT OF SILVER ORES AT COBALT, by Fraser D. Reid, J. J. Denny, and R. H. Hutchison 239-320

- Author's Preface to Chapter IV 239
- Summary of the Report 241
  - The Ore 241
  - Crushers and Crushing 242
  - Gravity Concentration—Low-Grade Ore 242
  - Cyanidation 242
  - Flotation 243
  - High-Grade Treatment 244
- The Silver Ores of Cobalt 246
  - General Characteristics 246
  - Suitability for Gravity Concentration 246
  - Suitability for Cyanidation 248
  - Cyanicides 248
  - Cyaniding Low-Grade Ore 249
  - Cyanide in Treatment of High-Grade Ore and Concentrates 250
  - Suitability for Flotation 251
- Crushers and Crushing 253
  - Introduction 253
  - Coarse Crushing 253
  - Intermediate Crushing 253
  - Gravity Stamp Best for Intermediate Crushing 253
  - Tube-Mills for Fine Grinding 254
  - Economic Limit of Crushing 254
  - The Cost of Crushing 258
  - Stamp Battery Practice at Nipissing 262
  - Rubber Liner for Tube-Mill 263
- Treatment of Low-Grade Ore 263
  - Introduction 263
  - Gravity Concentration 265
    - Preliminary Treatment 265
    - Treatment Below the Stamps 266
    - Outline of Coniagas Practice 268
    - Additional Notes on Gravity Concentration 272
  - Cyanidation 277
    - Early Practice 277
    - Development of Later Practice at Nipissing 281
    - Present Nipissing Practice 281
    - Summary of Nipissing Practice 283
    - Cobalt Reduction Company Practice 287
    - Additional Notes 289
    - Precipitation 291
    - Treatment of Precipitate 294
    - Sampling Milling Ore 295
    - Sampling of Table Concentrates 296
    - Aero-Brand Cyanide 296

PAGE

- The Flotation Process 297
    - Introduction 297
    - General Outline of Cobalt Practice 297
    - The Coniagas Practice 300
    - Additional Notes 303
- Treatment of High-Grade Ore 305
    - Introduction 305
    - Amalgamation and Cyanidation 306
        - The Nipissing High-Grade Mill 306
        - Additional Notes on Amalgamation 308
    - Cyanidation 315
    - The Hypochlorite Treatment 315
        - Cobalt Reduction Company Practice 315
    - The Acid-Wash Treatment 317
- Bibliography of Milling Practice at Cobalt 318

Chapter V.—Literature on Geology 321-358

- Introduction 321
- Summaries of Literature 322
- Appendix 356

MAPS AND PLANS
(In text of the Report)

- Map showing the location of Cobalt in relation to the other important mining areas of northeastern Ontario, namely, Sudbury, Porcupine, Kirkland Lake, South Lorrain, and Gowganda
- Plan showing general outline of some of the faults at Cobalt showing their approximate position on the surface 14
- General geological map of Cobalt area proper *Insert facing* 30
- Plan showing mine levels at Lawson (La Rose) 99
- Stope section on vein No. 1, O'Brien mine *Insert facing* 122
- Stope section on vein No. 6, O'Brien mine " " 122
- Geological Map of Peterson Lake Silver Cobalt Mining Company, Limited 168-169
- Plan showing location of leases which were granted from time to time by the Peterson Lake Mining Company 171
- Plan showing mine workings of Edwards-Wright (Green-Meehan and Red Rock mines) 175
- Stope section on Edwards-Wright (Green-Meehan) 176
- Plan showing workings in North Cobalt mine 180
- Plan of Genesee levels, furnished by Mr. L. F. Steenman 181
- Plan showing location of diamond-drill holes on Watash 186
- Plans of mine levels of Ophir and People's Silver 187
- Plan showing relative position of South Lorrain 189
- Geological Map of South Lorrain, scale one mile to 1 inch *Insert facing* 193
- Plan showing claims in South Lorrain 203
- Plan showing mine workings of Wettlaufer 224
- Plan showing mine workings of Maidens claim H.R. 69 231

MAPS AND PLANS
(In pocket at back of Report)

- Sheet 31a- 1—Beaver and Temiskaming Mines, showing plans of mine levels, scale 250 feet to 1 inch.
- Sheet 31a- 2—Crown-Reserve and Silver Leaf Mines, showing plans of mine levels, scale 250 feet to 1 inch.
- Sheet 31a- 3—Kerr Lake and Hargrave Mines, showing plans of mine levels, scale 250 feet to 1 inch.

Note.—Sheets 31a-4 to 31a-7 are insert maps bound in the report.

- Sheet 31a- 8—Penn-Canadian Mine, showing plans of mine levels, scale 250 feet to 1 inch.
- Sheet 31a- 9—Bailey, Foster and University Mines, showing plans of mine levels, scale 250 feet to 1 inch.
- Sheet 31a-10—O'Brien, Violet, and Colonial Mines, showing plans of mine levels, scale 250 feet to 1 inch.
- Sheet 31a-11—Nipissing, Coniagas, Trethewey, and Hudson Bay Mines, showing plans of mine levels, scale 400 feet to 1 inch.
- Sheet 31a-12—The Mining Corporation of Canada, Ltd. (City of Cobalt, Buffalo, Townsite, Townsite Extension, and Cobalt Lake Mines), showing plans of mine levels, scale 400 feet to 1 inch.

Sheet 31a-13—McKinley-Darragh, Nipissing, Silver Queen, Princess, Little Nipissing, and Right of Way Mines, showing plans of mine levels, scale 400 feet to 1 inch.
Sheet 31a-14—La Rose, Right of Way, and Chambers-Ferland (Aladdin) Mines, showing plans of mine levels, scale 400 feet to 1 inch.
Sheet 31a-15—The Productive Area of South Lorrain, scale 400 feet to 1 inch.
Sheet 31a-16—Keeley, Frontier, and Crompton Mines, showing plans of mine levels, scale 400 feet to 1 inch.
Sheet 31a-17—Provincial and Savage Mines, showing plans of mine levels, scale 400 feet to 1 inch.
Sheet 31a-18—Lumsden, Rochester, Adanac, Prince, Cochrane, and Columbus Mines, showing plans of mine levels, scale 400 feet to 1 inch.
Sheet 31a-19—Plan Showing Mine Workings under Cart and Peterson Lakes, scale 500 feet to 1 inch.
Sheet 31a-20—Map Showing Silver Veins in Cobalt Area Proper, scale 20 chains to 1 inch.
Sheet 31a-21—Map Showing Mining Claims in Cobalt Area Proper, scale 40 chains to 1 inch.

COLOURED SECTIONS

(In text of the Report)

PAGE
Vertical Section through North Part of Cobalt............................ *Insert facing* 8
Sheet 31a-5—Vertical Sections parallel to Veins Nos. 1, 2 and 3 on the Temiskaming Mine, and to Vein No. 5 on Beaver Mine...................... *Insert facing* 10
Vertical Section through Townsite, McKinley-Darragh, and Nipissing Mines... " " 12
Sheet 31a-4—Vertical Sections East and West through Beaver and Temiskaming Mines *Insert facing* 32
Sheet 31a-7—Vertical Section through Crown-Reserve Shaft and Silver Leaf North Shaft *Insert facing* 34
Sheet 31a-6—Vertical Section through University and Penn-Canadian Shafts... " " 40
Section along line A-B, showing dome structure of Nipissing diabase sill, South Lorrain *Insert facing* 207
Vertical Section along Vein 16 and through No. 3 Shaft, Keeley Mine, South Lorrain *Insert facing* 207
Stope Section on Wood's Vein, Keeley Mine............................... " " 216
Vertical Section through No. 1 Shaft, Frontier Mine........................ " " 219

FLOW SHEETS

(*Inserts*)

Mill flow-sheet, McKinley-Darragh-Savage Mines, January 1913............ *Insert facing* 264
Comparative flow-sheet, Cobalt milling practice, 1914........................ " " 274
" " " " " 1917........................ " " 276
" " " " " 1923........................ " " 278
Flow-sheet of low-grade mill, high-grade mill and refinery, Nipissing Mining Co., Ltd. *Insert facing* 280

"The ore is undoubtedly very rich, containing values in nickel, cobalt, silver, and arsenic, and a comparatively small vein could be worked at a handsome profit".—Willet G. Miller in the *Engineering and Mining Journal*, December 10th, 1903.

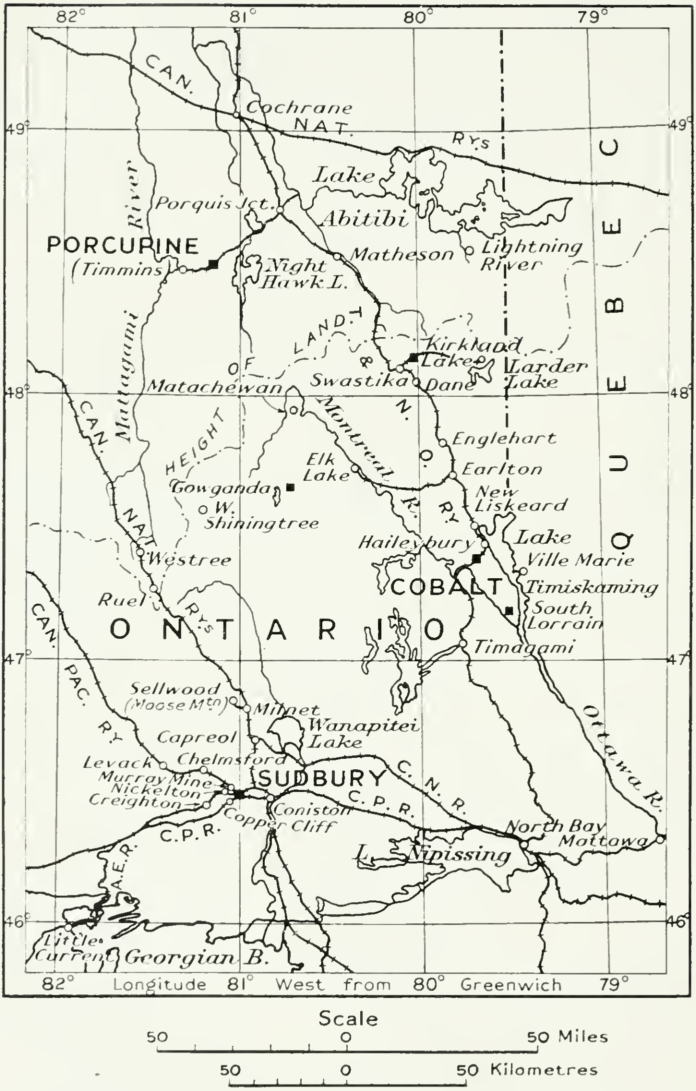


Fig. 1—Map showing the location of Cobalt in relation to the other important mining areas of northeastern Ontario, namely, Sudbury, Porcupine, Kirkland Lake, South Lorrain, and Gowganda.

AUTHOR'S PREFACE

In preparing this report the main object in view was to construct geological plans of all the mine workings in Cobalt and South Lorrain, and to put on record a brief description of the geology of these workings. This object has been, for the most part, accomplished; unfortunately a few of the mines were idle or flooded, hence no examination could be made of these properties.

The report may perhaps be regarded as supplementary in character to Dr. Willet G. Miller's well-known work on Cobalt, the last edition of which was published in 1913 in Volume XIX, part 2, of the Ontario Bureau of Mines Annual Reports. There still remain on hand copies of his report together with geological maps of the surface. For those who are not already familiar with the general geology of the camp, Miller's memoir should be read in conjunction with the present one.

In the year 1919 the mine managers of Cobalt requested the Ontario Department of Mines to undertake a detailed geological survey of the mine workings. The department acceded to their request, and the preparation and publication of this report were undertaken. If the report serves any useful purpose, it will be largely due to the mine managers who made possible the carrying out of the work. The writer wishes to acknowledge their co-operation and to thank them heartily for the many courtesies, social and otherwise, which were extended to him. Those who know Cobalt are familiar with the spirit of hospitality which exists there among mining men.

Messrs. Fraser D. Reid, J. J. Denny, and R. H. Hutchison have written the section of the report dealing with the milling and metallurgical practice in the treatment of silver ores at Cobalt. The preparation of their report entailed much arduous labour—given ungrudgingly and without remuneration of any kind. For them it was an unselfish piece of work done for the love and advancement of the science of milling and metallurgy. There are too few instances of such service for the public good. The Ontario Department of Mines and many engineers owe Messrs. Reid, Denny, and Hutchison a debt which will not be easily paid. The writer thanks them sincerely for their kindness in preparing the report.

To Mr. Thomas W. Gibson, Deputy Minister of Mines, the writer expresses his thanks not only for the sympathetic attitude which he took towards the work, but especially for his steady support in the way of procuring the appropriations which made it possible. The report has cost more than any other of its kind ever published by the Ontario Department of Mines. This cost was largely due to the expense of publishing the accompanying maps and cross-sections.

Cobalt was discovered in the summer of 1903, and in the fall of that year W. G. Miller began his geological work in the newly-found camp. Since the early spring of 1904 the author has assisted Dr. Miller in his labours in the Cobalt silver field. As a student prior to that time, the author gained his first knowledge and love of the science of geology from Dr. Miller who, before he became Provincial Geologist for Ontario, was professor of geology at Queen's University, Kingston. To all his old students Dr. Miller has, indeed, been guide, counsellor, and friend. This opportunity is taken to thank him for the many years of inspiring companionship and of unstinted advice.

During the course of the work Messrs. James Hill, T. R. Buchanan, J. M. Robb, and David Hill acted as valuable assistants. Acknowledgment is herewith made of their help. Mr. James Hill has, moreover, read and corrected much of the proof of the report.

Miss D. J. Ferrier has also very kindly read many pages of the proof.

Mr. W. K. McNeill, Provincial Assayer for the Province of Ontario, and Mr. T. E. Rothwell have kindly made the analyses which were necessary.

The department is indebted to a number of mining engineers who very kindly undertook to write an account of the discovery and early history of certain mines. Mr. Charles A. Richardson has given an interesting account of how the Temiskaming mine was discovered, and Mr. Norman R. Fisher has written concerning the early mining operations at this property. Mr. Walter E. Segsworth, who was largely responsible for the discovery of the Seneca-Superior, and who was its managing director, has furnished the department with an excellent report concerning the geology and history of that mine. Mr. Balmer Neilly has also written a description of the Penn-Canadian mine, and Mr. R. W. Brigstocke an account of the Drummond mine. In South Lorrain, Mr. Horace Strong kindly wrote the history of the Frontier mine, prior to its acquisition by the Mining Corporation of Canada, Limited.

The writer had the privilege of using an unpublished report dealing with the underground geology of Cobalt. This report, which was written by Alfred R. Whitman, was a private report, made for certain of the mine managers of Cobalt. A summary of Whitman's work appears in Chapter V.

Mr. W. R. Rogers, Statistician of the Ontario Department of Mines, has had the arduous task of compiling the figures showing the production of every mine in the entire Cobalt silver area.

The annual reports of the inspectors of mines for the Province of Ontario have been freely drawn on for information, particularly pertaining to the South Lorrain area. These reports will be found invaluable, especially to those desiring information concerning properties closed down and flooded. In the early days Mr. E. T. Corkill inspected the mines in the Cobalt camp. In later years Mr. T. F. Sutherland was appointed Chief Inspector of Mines. His reports, together with those of James Bartlett, J. G. McMillan, and E. A. Collins, inspectors of mines, give excellent accounts of the progress made from year to year at the various mines and prospects. Their reports also at times touch on the geology of the ore deposits and on the rock structures.

Finally the writer would like to make mention of the mining paper, published in Cobalt, called the *Northern Miner*. This robust little weekly is doing splendid work in promoting not only the interests of silver mining in the Cobalt area, but of mining generally throughout central Canada. It may be added that the *Nugget*, published in North Bay, is doing equally good work in furthering the mining industry.

C. W. K.

Toronto, April, 1924.

OUTLINE OF THE REPORT

The report deals with (1) that part of the Cobalt silver area surrounding and near the town of Cobalt, and (2) one of the outlying areas, namely, South Lorrain (Fig. 45). The area surrounding and near the town of Cobalt has produced 96 per cent. of the total output of silver from all parts of the field.

The report is divided into five chapters. The first chapter discusses the recent discoveries of ore-bodies; the total production of silver, cobalt, nickel, and arsenic in the entire camp including Cobalt, South Lorrain, Gowganda, and the other outlying areas; certain ideas regarding the deposition of the silver ores; the veins, faults, and so forth. A brief summary of the general geology of the camp will be found in this chapter.

Chapter II gives a detailed geological description of most of the mine workings in the area surrounding and near the town of Cobalt.

Chapter III deals with South Lorrain. It gives a history of that interesting camp, together with an account of the general geology, the ore deposits, and a detailed description of the mine workings.

Chapter IV treats of the mining and metallurgical practice at Cobalt. This section is written by Messrs. Fraser D. Reid, J. J. Denny, and R. H. Hutchison.

In Chapter V will be found a list of the reports and papers which have been published on the geology and mineralogy. A summary of many of these papers is given.

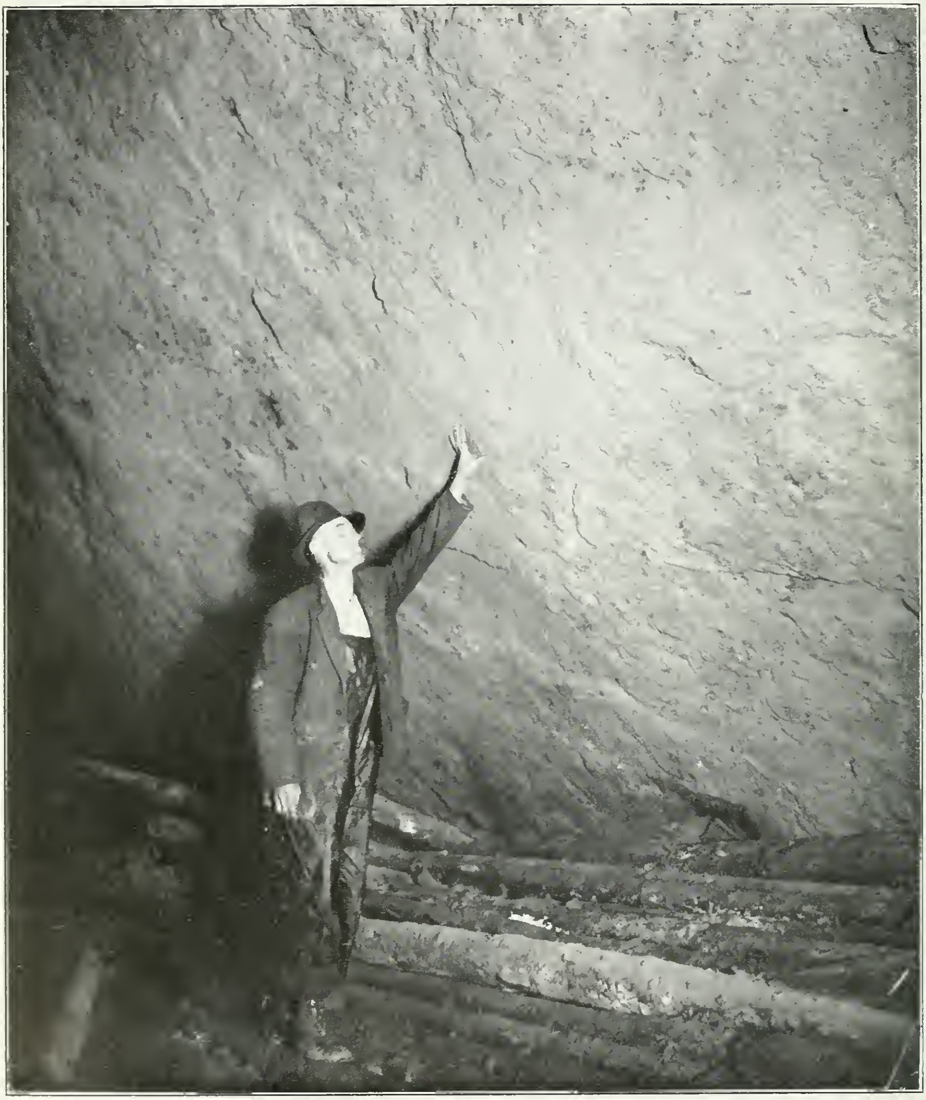


Fig. 2—McKinley-Darragh mine, Cobalt, showing stope in Cobalt lake fault, 350-ft. level. The fault is a reverse type with a displacement of about 550 feet at the McKinley-Darragh. The ore-shoot mined from this stope yielded about half a million ounces of silver.

CHAPTER I

INTRODUCTION

The rocks of the Cobalt silver field, as mining men now know, belong to that much discussed pre-Cambrian shield which stretches westward from the Atlantic ocean about three-quarters of the way across Canada. This immense region has of recent years been much written about in the annual reports of the great banking institutions of Canada, in the financial press, in the technical journals, and in daily newspapers which devote space to the mining industry. The eyes of a great part of the mining world are turned more and more towards this great prospective source of wealth. As a result the general public is commencing to get a faint inkling regarding its relation to the prosperity of Canada. In recent months it has, indeed, been the subject of a lively and prolonged controversy regarding its ultimate production of economic minerals. Although it may not, perhaps, be the province of this report to take any part in that controversy, nevertheless the writer cannot refrain from stating his belief, a belief held by most mining men, that there will be found untold riches in the pre-Cambrian shield as years go by. Including the great iron and copper mines in the Lake Superior region, the nickel of Sudbury, the silver of Cobalt, and the gold of Porcupine and of Kirkland Lake, the region has produced wealth amounting to many billions of dollars.

The writer may perhaps be pardoned for again alluding to the pre-Cambrian shield as he has done in the preceding paragraph. To some mining men in Ontario and elsewhere these remarks are now trite and commonplace. Government reports on mining subjects, however, often circulate into the farthest corners of the earth, and this report may, perhaps, tell the story of the pre-Cambrian to some who have not yet heard it. If the above remarks will serve in even a remote way to increase the stream of capital for mining purposes which is flowing towards Canada, particularly Ontario, the repetition will surely be justified.

Among the great silver fields of the world, Cobalt is only exceeded in silver production by the following three historic camps: Potosi in Bolivia, with a production of 30,000 metric tons of silver; Guanajuato in Mexico, with 15,000 metric tons; and Zacatecas in Mexico, with a production of 14,000 metric tons. Cobalt yielded 10,375 metric tons to the end of the year 1922. To the end of the year 1923, Cobalt produced a total of 343,895,780 troy ounces of silver.

In addition to this, to the end of the year 1922, Cobalt yielded $10,606,880 in cobalt and its compounds, $764,976 in nickel and its compounds, and $3,541,491 in arsenic and its compounds.

These figures regarding the production from the Cobalt field include Cobalt and all the outlying areas.

The amount of dividends compared with the quantity of silver produced is very large. The Nipissing, as the late Mr. R. B. Watson pointed out, has paid to its stockholders in dividends 66 per cent. of all the money received by the Company.

The most striking development in the Cobalt silver field in the past two years has been the discovery of high-grade ore in South Lorrain at the Keeley and Frontier mines. This has been the means of renewing a more general interest in silver mining. The promising development, too, at the Colonial and Genesee mines in the fall of 1923, has been a cheering influence. And the discovery of a strong vein of cobalt ore, containing small patches of high-grade silver, under a drift-covered area at the Ruby has raised hopes in that section.

These recent discoveries, combined with the fact that the silver-bearing rocks extend across a stretch of country, not yet intensively prospected, at least 70 miles long (Fig. 44) appear to justify the belief that mining of silver will continue to be carried on somewhere in this area for many years to come. In the words of Mr. R. B. Watson, "It takes a long time for a good camp to die."

In a mining way the most interesting development of recent years has been the treatment of great quantities of low-grade ore. The Coniagas, for instance, in the last two years has been milling ore which averaged only between eight and ten ounces of silver per ton. The stopes throughout the camp have been mined to much greater widths than was the case in the early days when only high-grade ore was extracted. The ore in these wide stopes—in one case over 80 feet in width—consists of country rock which has been mineralized along tiny cracks with thin leaves of native silver or other silver ores.

Fig. 3—Railway station at Cobalt, 1922.

It is not the province of this report to publish again a full account of the general geology of the Cobalt silver area. That has already been done years ago by Miller. But a brief summary of the geology may be found useful for those who do not happen to have a copy of Miller's report at hand. It will be recalled that the silver deposits are associated with a great sheet of diabase a thousand feet thick. This sheet penetrates beds of sedimentary rocks consisting of conglomerate, quartzite, and greywacké. The sediments rest on Keewatin basalt; the diabase sheet also penetrates the Keewatin. The deposits consist of narrow, generally vertical veins, averaging three or four inches wide, cutting the sediments, the diabase sheet, and the Keewatin. The silver occurs chiefly in the native form. A fuller summary of the general geology will be found elsewhere in this report.

In connection with our knowledge of the veins there have been two outstanding developments in the last decade. The first of these developments has been the gradual realization that most of the silver in Cobalt occurs at the base of the sedimentary rocks, the Cobalt series, immediately above the Keewatin rocks (Fig. 5). This contact has proved to be the most productive ore horizon in the camp. The depth of this contact zone is, indeed, shallow—between 100 and 200 feet above the contact between the Keewatin and Cobalt series.

The second outstanding development is the recognition that faults appear to have played an important part in the formation of some of the ore shoots. That is to say, certain faults, older than the ore bodies, appear to have acted as barriers or "dams" by confining the deposition of the silver ores within certain restricted areas. The Beaver-Temiskaming ore shoots, for example, are terminated at the north end by a fault.

The recognition of deep-seated, pre-glacial weathering by J. Mackintosh Bell at the Keeley mine in South Lorrain has been a notable feature.

Another point of interest regarding the ore-bodies is the growing belief among geologists that the veins are, in part at any rate, replacement types. That is to say, the mineral-bearing solutions have found their way along joints and faults and have replaced the wall rocks as deposition took place. Open fissures are believed to have been uncommon.

Of interest, too, is Mr. J. E. Spurr's recent announcement of his belief that the veins of Cobalt belong to a class of deposits which he has named *vein dikes*.

Our knowledge of the number and location of the veins has increased in recent years on account of the great amount of development work which has been carried on. Mining operations have revealed an amazing net-work of veins, the intricacy of which is shown on plan No. 31a. Many of these veins do not outcrop on the surface and hence the early maps do not show all the ore-bodies. The plan brings out the fact that the veins are found in what have been called by mining men in Cobalt *vein-systems*. These vein-systems occur in a somewhat isolated manner separated by barren areas. Examples of some of the vein-systems are the Beaver-Temiskaming, the Kerr Lake-Crown Reserve, the Meyer-Coniagas-Trethewey system, and so on.

The faults in the area around the town of Cobalt have now for the first time been mapped. It has been found that pay ore occurs in some of these faults, including the greatest in the camp, namely the Cobalt lake fault.

Area Covered by Report

The Cobalt silver area includes a number of silver-producing localities occurring across a stretch of country 70 miles in length, from the southeast to the northwest (Fig. 45). Chief among these is the Cobalt area proper which comprises the locality surrounding and near the town of Cobalt; this area of about five square miles has produced 96 per cent. of the entire production to the end of the year 1922. Next in point of interest, at the moment, is South Lorrain, about 16 miles southeast of the town of Cobalt, which has produced 1.4 per cent. of the entire production to the end of the same year.

It is with these two localities, the area around and near the town of Cobalt and the South Lorrain area, that this report deals. Statistics, however, referring to the entire camp, including Cobalt and the outlying areas, are given.

Descriptions of the other areas, namely, Gowganda, Casey township, Cane and Auld, Shining Tree, Maple Mountain, Bay Lake, and Wendigo, will be found in Dr. Miller's report referred to in the Preface. An excellent report was also made on Gowganda by A. G. Burrows, the fourth edition of which was published in the thirtieth annual report of the Ontario Department of Mines in the year 1920.

When Work Was Done

The work of examining the mines was begun in the spring of 1920, during which year five months were spent in a detailed geological survey. In 1921, seven months were similarly devoted to the task; while in 1922, one month was spent mostly in South Lorrain. In the spring of 1923, about two weeks were devoted largely to the examination of certain properties which had become accessible in the meantime, namely, the Seneca, La Rose Extension, Genesee, Ruby, and the deep shaft on the Colonial. During the latter part of January, 1923, a brief visit was paid to the Keeley mine, for the purpose of photographing vein No. 26 which developed an extraordinary width of high-grade ore at one place (Fig. 50).

Preliminary Report

As the work had extended over a period of about three years' time it was thought desirable to issue a preliminary report. This report, under the title "Cobalt—Its Past and Future," was published on May 6th, 1922, in the Engineering and Mining Journal-Press of New York. In August of the following summer, 1923, the complete report on South Lorrain was published as Bulletin No. 48 of the Ontario Department of Mines. This forms Chapter III of the present report. At the same time that this bulletin was published, the report on the milling and metallurgical practice at Cobalt, by Messrs. Reid, Denny, and Hutchison, was issued as Bulletin No. 47. This is Chapter IV of the present report. In publishing these parts separately before the entire report could be issued, the department acceded to a demand from certain quarters to give some sort of preliminary statement prior to the publication of the final report. These separate reports made it less urgent to hurry the publication of the final report.

It may be added that when the writer first undertook the work, and during its early progress, it was sometimes remarked to him, by certain individuals, that the report would be largely of the nature of a *post mortem*. The work was begun several months before the important discoveries were made in South Lorrain at the Keeley and Frontier mines. These discoveries in South Lorrain have proved that the *post-mortem* report on the Cobalt silver camp may not be written in our generation, and probably not, let us believe, for many years to come. The recent utterances of certain well-known mining men confirm this view.

Maps Accompanying Report

In the map case accompanying this report will be found a set of geological plans. These plans represent in a detailed manner the geology of practically all of the mine levels in Cobalt and South Lorrain. They show the kinds of rocks, the veins, the faults, and the position of the drifts, crosscuts, shafts, and so forth. No such complete set of geological plans showing the mine workings has been published of any of the other important mining camps in Canada; and there are few camps in the United States which have had published similar geological plans of all the levels. The Comstock lode in Nevada is an outstanding exception.

The plans show only one vein in the drifts, the veins being indicated by a red line. It may be pointed out, however, that in many places there may be two or more parallel veins in the same drift, but on the small scale on which the plans are published it was not possible to show the vein systems in all their complexity.

The drawing and preparation of the plans and sections was accomplished mainly by Mr. A. Braidwood. Mr. H. C. Smith also did much of this work. The task of reducing and compiling the hundreds of mine level plans to a uniform scale required some two years of painstaking labour, and Messrs. Braidwood and Smith are to be complimented on the excellent character of their work.

As the report deals essentially with the underground geology it was not thought advisable, on account of the added expense, to reprint all of the geological surface maps which accompany Miller's report. Only one of these surface maps accompanies the present report on Cobalt. These surface maps are still in print and may be obtained, together with Miller's report, from the Ontario Department of Mines, Toronto. That on a scale of 400 feet to the inch will be found especially useful. In the case of South Lorrain, however, a new detailed surface map showing the geology and contours of the productive part of the area will be found in the map case accompanying the report. There is also a reprint of part of A. G. Burrows' plan of South Lorrain, scale one mile to the inch.

THE ORES AND HOW THEY OCCUR

Grade of Ore.—As is well known among mining men, the silver veins are exceedingly rich, containing from one or two hundred troy ounces of silver to the ton to as high as five or ten thousand ounces. In recent years, however, the wall-rock of these high-grade veins in certain properties around Cobalt lake is being treated, and ore as low as eight to ten ounces per ton is now being mined at a profit. Most of this low-grade ore occurs in rocks of the Cobalt series.

Depth of Ore-Shoots.—The silver from Cobalt has been obtained from a shallow zone, most of the ore having been mined from a depth of not more than about 300 feet.

The greatest depth at which pay ore has been encountered is a little less than 1,000 feet. This ore, which was mostly a good grade of mill-rock, was found at the Colonial mine in the fall of 1923; a comparatively small quantity had been shipped.

A very little silver, some 40,000 ounces, was reported by F. L. Culver to have been mined in the Beaver at a depth of 1,600 feet.

Why the Silver Disappears When Veins Pass from Cobalt Series into Keewatin.—More than 80 per cent. of the silver has been obtained from veins in the Cobalt series. Many of these veins in this series pinch or feather out into stringers on reaching the underlying Keewatin. Veins of this type generally occur in joint planes as distinguished from faults; the fractures were not, apparently, strong enough to pass downward into the tougher Keewatin. The disappearance of silver at the Keewatin contact in veins of this type is thus readily understood.

In the case, however, of veins which persist to unknown depths into the Keewatin, but which lose their silver contents at or near the Keewatin contact, the explanation of the loss of silver at the contact is more difficult. Generally speaking, it is only the stronger fractures, such as faults, which persist into the Keewatin. Vein No. 64 on the Nipissing, for example, occurs in a prominent fault. This vein was explored downward into the Keewatin for 800 feet, but no pay ore was found in the Keewatin although the calcite vein persisted (Fig. 4).

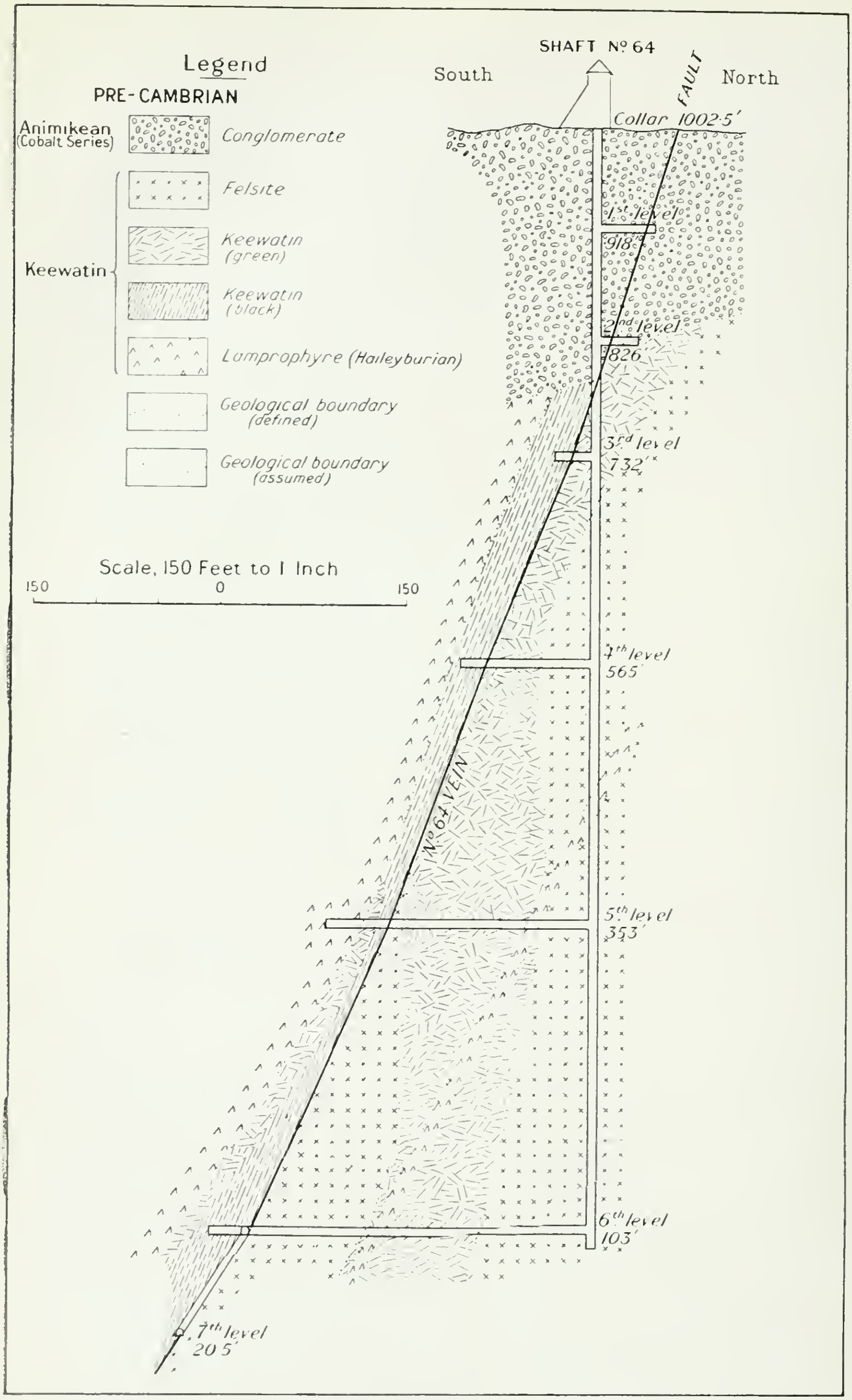


Fig. 4—Vertical section through shaft No. 64, Nipissing mine, showing vein No. 64. This vein occurs in a fault. The vein was productive in the Cobalt series, but no ore was found in the Keewatin rocks below the Cobalt series, although the vein persisted to the bottom of the workings. Section furnished by the Nipissing Mining Company. Elevations are shown in feet above sea level.

Miller explains the disappearance of silver at the Keewatin contact in veins of this class in the following manner.[1]

> In the case of a vein which passes from the Cobalt series into the Keewatin and carries high silver values in the former and not in the latter, the variation in values is to be accounted for by the fact that there have been two periods of deposition of the ore minerals. The first minerals to be deposited after the cracks were formed were essentially the cobalt-nickel arsenides. After these minerals were deposited there was a slight disturbance of the rocks, and the veins were slightly fractured and opened, giving an opportunity for the deposition of the silver minerals which were then percolating through the rocks. The Cobalt conglomerate and slate-like greywacké, being not highly metamorphosed and lying on the Keewatin or in contact with the diabase, were affected by the secondary disturbance, while the great mass of tough Keewatin rock for the most part escaped the disturbance and the veins in it were not fractured so as to give access to the silver solutions.

Relative Quantities of Silver in the Several Rock Series.—Mr. G. R. Mickle in 1912 estimated the relative quantities of silver in the various formations. He found that over 82 per cent. of the silver came from the Cobalt series, 10.85 per cent. from the Keewatin, and 7 per cent. from the Nipissing diabase.[2]

Ninety Per Cent. of Silver from "Lower Contact".—After twenty years of mining in the Cobalt silver field it is now possible to compare (1) the quantity of silver obtained from the top, or "upper contact" of the Nipissing diabase sill or rocks just above the top, with (2) the quantity of silver obtained from the bottom or "lower contact" of the sill or rocks just below the bottom. And it has been found that by far the greater portion has been obtained from the "lower contact." This contact has, indeed, produced approximately 90 per cent. of the total output, including Cobalt, South Lorrain, Gowganda, Casey township, Montreal River, and Maple Mountain.

The mines which produced their silver from the top of the sill, or upper contact, are the Temiskaming, Beaver, Adanac, Lumsden, Rochester, Nova Scotia, Colonial, King Edward, and Silver Cliff, in the Cobalt area proper; while in South Lorrain and Gowganda all of the output has come from the "upper contact." Every other producing mine of importance in the entire field has yielded its silver from the "lower contact" or rocks just below the lower contact. It may be added that in the fall of 1923 the Colonial mine began to produce a little silver from the lower contact, the previous production from the mine having come from the upper contact. A relatively small, non-commercial quantity of silver was also obtained from the lower contact at the Beaver.

The finding of silver in the deep levels of the O'Brien, Colonial, and Violet workings along the bottom of the Nipissing diabase sill, the "lower contact", opens up a vista of possible ore-shoots which may be contemplated with more satisfaction by the geologist than by the mining engineer. This lower contact extends to the eastward for three and a half miles, and is virgin territory except for a small amount of development work at such properties as the Ruby, Edwards-Wright (Green-Meehan), Agaunico and other mines. But the investigation of this unexplored "lower contact" will require much money, is speculative, and will be looked at with question by mining engineers unless some vein of more or less promise is discovered to lead the way. The veins on the Colonial and Violet are now leading in the direction of the unexplored and unknown. Not far to the east these veins may have to face possible vicissitudes, or enrichments, in the vicinity of the Cross lake fault or branches thereof.

---

[1] Ont. Bur. Mines, Vol. XIX, pt. II, pp. 123-124.

[2] The Probable Total Production of Silver from the Cobalt District, Jour. Can. Min. Inst., 1912.

Why More Veins in the Cobalt Series than in the Other Rocks.—Most of the veins are found, as already stated, in rocks of the Cobalt series. If the reader will study, for a moment, the coloured cross-section facing page 8 he will obtain some conception of the reason this should be so. The cross-section shows that the Cobalt series forms a comparatively thin stratum of sediments with the great mass of Keewatin below, and the enormous sheet of Nipissing diabase above. The Cobalt series is, indeed, sandwiched between two great igneous masses, which differ from it entirely in character. The Cobalt series is more brittle than either of these masses. If we imagine, then, the three groups of rocks subjected to certain stresses it does not seem unlikely that the more brittle group, the Cobalt series, should develop more fractures than the tougher Keewatin and Nipissing diabase.

It is of interest to add that only at Gowganda has silver been found in the Cobalt series above the Nipissing diabase sill. Mr. A. G. Burrows states that the Millerett in Gowganda produced 500,000 ounces of silver from the Cobalt series above the top of the Nipissing diabase sill.[1]

Factors Governing Formation of Silver Ore-Shoots

The ore-shoots in the veins consist of those parts of the veins which contain commercial quantities of silver as contrasted with the barren parts containing calcite and other minerals but no silver. The smallest shoot may be only a few feet in length; the longest, hundreds of feet. The longest shoot is that in the Meyer vein on the Nipissing and Trethewey.

It is of importance to know something about the factors which govern the formation of ore-shoots as distinguished from the barren parts of the veins.

In a broad, general way it may be said that the dominating factor in the deposition of the ore-shoots is the Nipissing diabase sill. Wherever silver ore occurs, there also will be found the Nipissing diabase. No silver ore-shoots occur in the entire camp where the diabase sill is absent.

Next in importance in guiding the deposition of silver ore-shoots appears to be the influence of contacts.

There are three contacts along which the silver ore-shoots have been found. The first and most important contact is that between the Keewatin and Cobalt series. The second contact is that along the bottom of the Nipissing diabase sill. And the third is that along the top of the Nipissing diabase sill.

The contact between the Keewatin and the Cobalt series governs the formation of 80 per cent. of the silver ore. It may be said that all the ore-shoots in the Cobalt series follow along the Keewatin contact and do not rise, as a general rule, more than 100 to 200 feet above the contact. Examples of some of the ore-shoots which occur along this contact are given in following paragraphs.

One of the best examples of the way this contact controls the occurrence of the ore is that of the Meyer vein in the Nipissing and Trethewey mines. The Meyer vein extends westward into the Trethewey, and the total length of the ore-shoot on the Trethewey and Nipissing is about 1,600 feet. The shoot, which is all in the Cobalt series, only rises an average height of about 110 feet above the Keewatin (Fig. 5).

The figure shows how the ore-shoot pitches down along the dip of the contact between the Cobalt series and the Keewatin series. The part of the vein above the ore-shoot consists of barren calcite. It may be added that the late Mr. R. B. Watson, the general manager of the Nipissing mine, first explained to the writer how the Meyer ore-shoot followed down along the Keewatin contact.

---

[1] Ont. Dept. Mines, Vol. XXX, pt. III, p. 3.

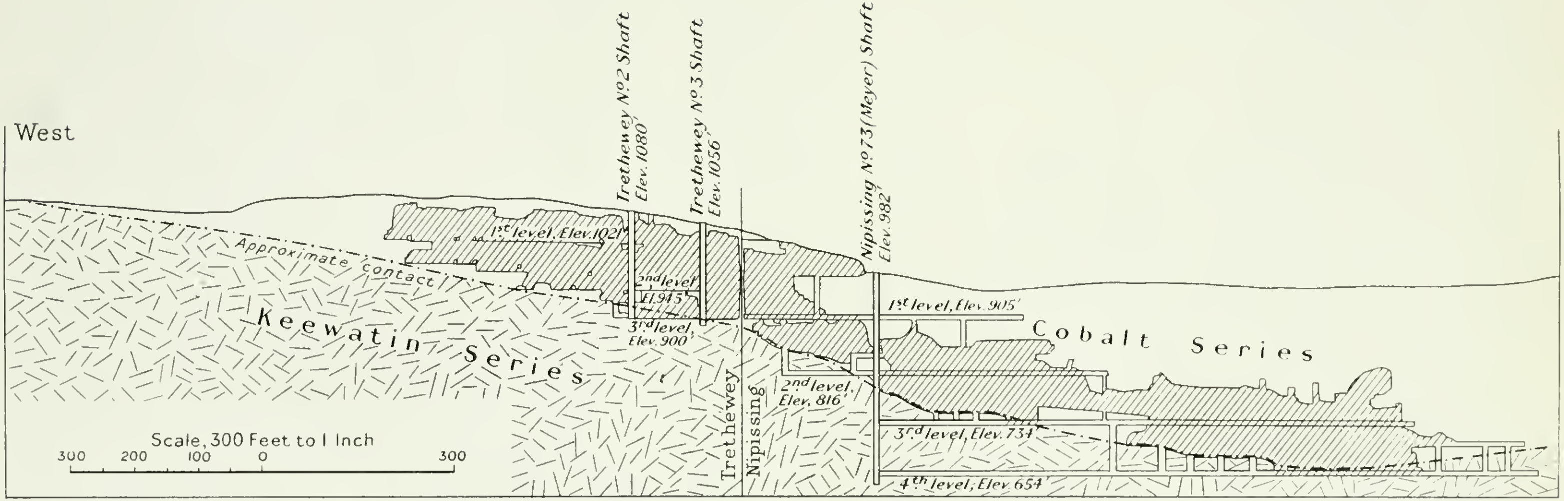


Fig. 5—Stope section on the Meyer vein of the Nipissing and the "main" vein on the Trethewey. The ore-shoot has a length of about 1,600 feet. The ore occurs almost entirely in the Cobalt series. On the Nipissing, the ore-shoot only rises above the Keewatin an average height of about 110 feet; above the stope the vein is a barren calcite vein about three-quarters of an inch wide. Stope sections furnished by the Nipissing and Coniagas.

Another example of the way the contact controls the formation of the silver ore-shoots is the vein-system at the northeast corner of the City of Cobalt mine owned by the Mining Corporation of Canada. The chief veins of this system are known as No. 24 and No. 32. This system of veins, which has a length of some 600 feet, also occurs in the Cobalt series. The ore-shoots in the veins only rise above the Keewatin contact from 100 to 175 feet, above which the veins consist of barren calcite. Indeed, they do not appear to reach the surface, except as narrow joint cracks containing calcite, fractions of an inch wide. The Cobalt series in this area has a thickness of about 400 feet.

Vein No. 490, on the east side of the Nipissing north of Cobalt lake, is another good instance of the way the ore-shoots follow the Keewatin contact. The shoot in this vein is about six or seven hundred feet long, but it does not rise more than about 150 feet above the contact.

So far as the writer can ascertain the first one to publish the fact that the ore-shoots follow the Keewatin contact was Mr. R. B. Watson, in 1912, in the fifth annual report of La Rose Consolidated Mines Company. Mr. Watson remarks: "The experience in the district has been, that while the conglomerate is the most favourable formation for ore, the ore-bodies usually lie in the vicinity of the Keewatin contact."

The practical importance of a knowledge of this structure need hardly be mentioned here. It must now be clear to anyone that the most promising place to prospect in the area surrounding Cobalt is near the base of the Cobalt series.

The second contact controlling the formation of ore-shoots is the top of the Nipissing diabase sill, sometimes referred to as the "upper contact." All of the ore so far discovered in South Lorrain occurs along the top of the sill, mostly within two or three hundred feet above or below the contact. In Cobalt itself, practically all of the ore at the Beaver and Temiskaming has been derived from the top of the sill, mostly within 200 feet above or below the contact. The structure of the Nipissing diabase sill and the relation of the veins to the sill at the Beaver and Temiskaming are shown in the coloured cross-sections facing pages 10 and 32.

The third contact controlling the deposition of the ore-shoots is the bottom of the Nipissing diabase sill, sometimes referred to as the "lower contact." All of the ore at the O'Brien and Violet mines has been derived from this contact. The structure at the O'Brien and Violet is illustrated in the coloured cross-section facing page 8. In one instance, that of No. 3 vein at the Kerr Lake mine, the ore-shoot rose to the middle of the sill; it may even have extended to the top of the sill, but erosion has carried away the upper half of the sill at this point. This is the only instance the writer knows in Cobalt in which an ore-shoot extended into the centre of the diabase sill. In Gowganda, however, A. G. Burrows has found that the silver veins at No. 1 shaft of the Castle, R.S.C. 101, are apparently near the centre of the sill.

Another factor governing the control of ore-shoots is the occurrence of faults older than the veins. These faults appear to have acted, in places, as dams or barriers in confining the occurrence of ore-shoots to certain areas. One of the best examples is the Beaver fault, which occurs at the north end of the Beaver-Temiskaming vein-system. No pay ore has been found north of this fault, although some rich ore occurred in the fault itself. Another fault which appears to have governed the deposition of ore-shoots, is that known as No. 64 at the north end of the town of Cobalt (Fig. 8). Only a few hundred thousand ounces of silver have, as yet, been found north of this fault. Nevertheless the discovery of some high-grade ore in the fall of 1923 at the Genesee mine, which lies about half a mile north of the fault, lends hope for the discovery of silver ore-shoots under the drift-covered area in and near Genesee.

It should be noted here that the best ore does not necessarily occur along the actual contacts, whether the diabase contacts or the Keewatin-Cobalt series contacts. In some veins there is no pay ore at the actual contact, the ore being from 50 to 100 feet, or more, above or below the contact.

It is a fact that no pay ore, in any important quantity, has yet been found where the Keewatin is absent. Contacts, for example, between the quartzite and Nipissing diabase have not proved productive zones for the deposition of silver.

The occurrence of silver ore under lakes at Cobalt is of interest. Many million ounces have been mined from veins below Kerr, Cart, and Cobalt lakes. It may be that one of the main reasons for the occurrence of ore under these lakes is that the lakes represent lines of weakness or disturbance. Exploration of the rocks below Lake Timiskaming has been, to the end of 1923, neglected. To digress, for a moment, from the Cobalt silver area, it may be noted that in the case of gold, the rocks near or below certain lakes have also been productive of great wealth in Ontario. Pearl lake in Porcupine, and Kirkland lake in the Kirkland lake area have yielded much gold. The Argonaut ore-body is also below a lake—York lake. The only iron mine in Canada of any consequence, the Helen mine, is also below a lake.

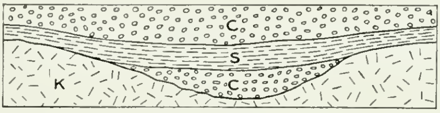


Fig. 6—Ideal sketch showing conglomerate of Cobalt series filling an erosion valley in Keewatin; a bed of slate-like greywacké rests on the conglomerate above the middle of the trough, but directly on the Keewatin on the upper side of the trough. The structure shows that the trough in the Keewatin is largely caused by erosion, not by folding. Structures similar to this occur below or near the beds of Cobalt and Cart lakes.
K—Keewatin series. C—Conglomerate of Cobalt series.
S—Slate-like greywacké of Cobalt series.

Veins in Cobalt Series Above Depressions in Keewatin

The occurrence of certain vein-systems in the Cobalt series, above or near depressions or troughs in the Keewatin, is an interesting feature of the ore deposits in the Cobalt silver area proper. The most noteworthy of such occurrences was pointed out to the writer by Mr. Warren Emens, geologist of the Mining Corporation of Canada. This occurrence was found by mining operations to exist in an area included in the Buffalo, Townsite, City, and Cobalt lake properties. If the reader will examine, for a moment, the plan No. 31a-12, of these properties, he may observe that this trough is developed on the third, fourth, fifth, and sixth levels. The trough, which strikes southeastward, is shown by the contour of the contact between the Keewatin and the Cobalt series. Many important veins occur above this trough.

Another instance of the occurrence of important veins above a trough in the Keewatin was noted in the Crown Reserve and Kerr Lake mines. The well-known Carson, the Big Chamber, and other veins occur above this trough.

The Meyer vein-system on the Nipissing also appears to occur above a slight trough in the Keewatin. This trough is not as marked or as deep as those referred to above. Indeed, the trough on the Nipissing is only apparent on the third and fourth levels, shown by the contour of the contact between the Keewatin and Cobalt series.

These troughs appear to the writer to have been formed by erosion in the old Keewatin surface (Fig. 6). Possibly a little folding, after the Cobalt series was laid down, may have accentuated the troughs.

Faults

In recent years it has been found that silver ore occurs in many of the prominent faults of Cobalt and South Lorrain. It has been demonstrated, also, that faults have acted as dams or barriers in confining the deposition of silver to certain areas. These two facts, combined with the constant encountering of faults in the mine workings, have led to a close study of faults.

Miller has shown that the region in and around the Cobalt silver area has been subjected to great faulting disturbances, chiefly in a northeast-southwest and a northwest-southeast direction. These faults, which follow the great water courses, divide the rock formations into immense blocks.

We are concerned in this report only with a discussion of the faults around the town of Cobalt, and with the faults in South Lorrain. Something will also be said regarding the Lake Timiskaming fault.

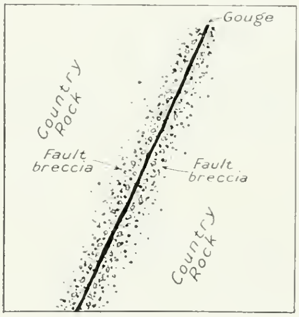


Fig. 7—Drawing illustrating character of faults in the Cobalt area. The heavy black line in the centre represents the gouge, which consists of soft clayey material and fine particles of crushed rock; it is usually less than an inch in width. In places there are two or more gouge planes, about parallel, and a few inches to a foot or two apart. The fault breccia, represented by dots and irregular lines, consists of fine and coarse fragments of the country rock, together with a little clayey material. The fault breccia varies in width from an inch or two, in minor faults, to as much as 15 or 20 feet in the case of a major fault like the Cobalt lake fault.

In describing faults throughout this report, the terms "gouge" and "fault breccia" have been used. Following Lindgren,[1] gouge refers to the fine-grained impervious clay, usually a mixture of minerals. Fault breccia refers to the breccia of crushed wall-rock which occurs in the faults. There is usually some clay in the matrix of the fault breccia (Fig. 7).

In certain of the faults at Cobalt the gouge and the fault breccia are sharply distinguished one from the other. That is to say, the gouge may occupy a distinct fracture with smooth walls, the fault breccia being on each side of the gouge. In other faults, the gouge and fault breccia are scarcely distinguishable, the gouge then forming a matrix for the fault breccia.

The main faults in the vicinity of Cobalt and Cross lakes are shown in Fig. 8. They are mostly reverse types, but some are normal. The greatest is probably the Cobalt lake fault, although little is as yet known about the Cross lake fault.

The Cobalt lake fault is a reverse one with a displacement of about 550 feet at the McKinley-Darragh mine. Proceeding northeastward, however, the displacement becomes less, until at La Rose the displacement is approximately 275 feet. The fault dips 50° to 70° to the southeast. It may be that many of the other faults and fractures in the vicinity of Cobalt lake are the result of stresses connected with the Cobalt lake fault.

---

[1] Lindgren, Waldemar, Mineral Deposits, 2nd ed., p. 124.

Another important fault, though one of less displacement, is that known as the "valley" fault. It is west of the Cobalt lake fault and is shown on the plan (Fig. 8), at the north end of the camp. It is also a reverse fault with a displacement of 75 feet at the point where it could best be studied. It dips 45° to 65° to the southeastward.

West of the Cobalt lake fault and the "valley" fault there occurs a much more gently dipping fault known as the "contact" fault. It is so named because it follows, in a general way, the contact between the Keewatin and Cobalt series, Fig. 20. For the most part it occurs in the Cobalt series a few feet above the Keewatin series, though in places it is found in the Keewatin. Rarely does it occur precisely at the contact. On the Buffalo and Townsite where the fault spans a trough in the Keewatin, the fault is some distance above the Keewatin (Fig. 17). Judging from its occurrence on the Trethewey, the "contact" fault is a reverse one. The displacement is probably less than the "valley" fault. The "contact" fault has been met with again and again in the mine workings of the Mining Corporation properties, the Coniagas, and the Trethewey. Its age relation to the veins is puzzling.

It is likely that the Cobalt lake fault, the "valley" fault and the "contact" fault have all been formed as the result of a compressive force acting from the northwest towards the southeast, and from the southeast towards the northwest. Most of the strain was relieved along the Cobalt lake fault; a lesser amount was relieved along the "valley" fault, and probably a still less amount along the "contact" fault. The three faults are roughly parallel and strike northeastward. These faults are shown in the coloured cross-section facing page 8; in this cross-section the "contact" fault is named the Trethewey fault.

Another group of faults, west of the Cobalt lake fault, may be described together. The faults constituting this group almost parallel one another and strike a little south of east, or about at right angles to the Cobalt lake, "valley," and "contact" faults. The faults of this second group are named, beginning with the southerly one: fault X, galena fault, No. 6 fault, an unnamed fault in the deep bay of Sasaginaga lake, and fault No. 64. Two of these, No. 64 and fault X, have proved to be normal faults with a displacement of less than 25 feet; there may have been some horizontal movement. All of them have vertical or steeply inclined southward dips. Three of these faults have silver ore in them particularly fault No. 64 on the Nipissing, which has been one of the important producers of this company (Fig. 4). This fault appears to form a boundary line at the north end of the camp beyond which a comparatively small quantity of silver has been found. High-grade silver ore, however, was found at the Genesee in the fall of 1923, and also occurs at the Green-Meehan, two miles northeast of the fault, and at the Casey mine 13 miles north of the fault.

Little is known about the Cross lake fault. It occurs in a pronounced valley formed by Cross lake and a string of lakes to the southeast. The writer has never seen the fault in any mine workings. It is reported to have been encountered in a crosscut from one of the workings at the northwest end of the lake. Much water was said to have been encountered. Fault No. 64 strikes towards the Cross lake fault and appears to be a branch of this fault; this remains to be proven by actual mine workings.

Besides the faults shown on the plan (Fig. 8), there are other faults of importance. One of these is found on the lower levels of the Crown Reserve, paralleling the longer axes of Kerr lake. Another one of much importance occurs at the Beaver mine at the north end of the ore-shoots. The faults referred to in this and preceding paragraphs are described in much more detail in dealing with the various mines.

It may be added that fault No. 64 has not been traced continuously from the Hudson Bay to the Violet mine. It has been drifted on for long distances in the Hudson Bay, Trethewey, Chambers Ferland, La Rose, O'Brien, and Violet, and its character is similar throughout. The fault has not, however, been followed through the Cobalt lake fault. It is not at all certain, therefore, that

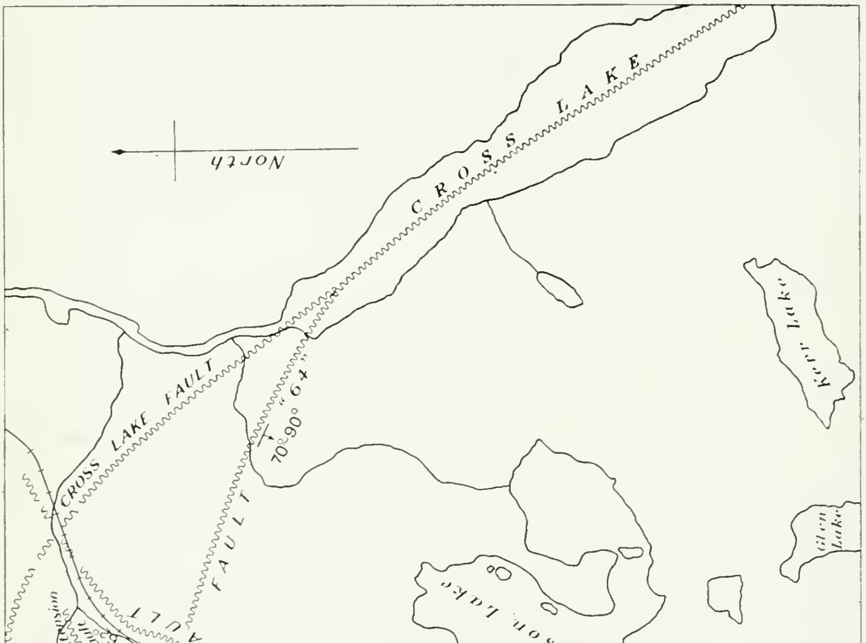


Fig. 8—Plan showing general outline of some of the faults at Cobalt showing their approximate position on the surface. The drawing is intended to give only a general idea of the faulting system. The exact locations of the faults on the various levels of the mines are shown on the detailed plans of the levels. These plans are in the map case accompanying the report. The fault immediately north of Cart lake dips to the northeast—not to the southwest as shown on the plan.

what has been called fault No. 64 west of Cobalt lake fault, is really the same fracture that has been called fault No. 64 east of the Cobalt lake fault.

It has been erroneously remarked that the silver deposits of South Lorrain differ from those of Cobalt in one important respect, namely, that the South Lorrain deposits occur in faults, while the ore bodies in Cobalt occur in mere fractures. As a matter of fact, at Cobalt some very important ore bodies occur in faults which have greater displacement than those of South Lorrain. Important ore bodies have, for example, been found in the Cobalt lake fault. Much ore has also been mined from fault No. 64 on the Nipissing. On the whole, however, most of the ore from Cobalt has come from joint planes showing little or no movement.

Coming now to South Lorrain, little need be added to the description of the faults given on page 194 of the chapter on South Lorrain. Economically the most important one is Wood's fault, a reverse one with a displacement of approximately 30 feet. Most of the ore mined during the last two years in South Lorrain has come from this fault or from branches thereof.

Of all the faults briefly referred to above there are none which appear to compare in magnitude with the Lake Timiskaming fault.

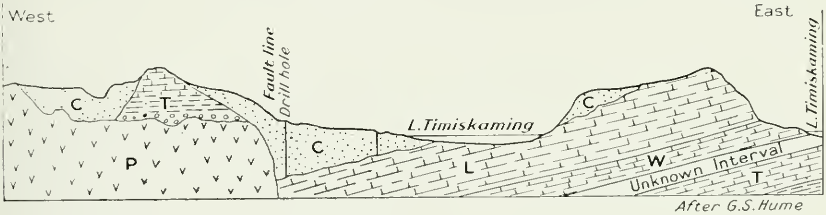


Fig. 9—Vertical section, east and west through New Liskeard; horizontal scale 2 miles to an inch, vertical scale 800 feet to an inch. The Lake Timiskaming fault is shown at "fault line." The rocks on the east side of the fault have been faulted down 800 to 1,000 feet.

C—Post Glacial clay.
L—Lockport formation } Silurian.
W—Walsi formation }
T—Haileyburian—Ordovician.
P—Pre-Cambrian.

Lake Timiskaming Fault.—Willet G. Miller was the first geologist to detect the presence of the Lake Timiskaming fault.[1] No mining operations have as yet been carried on in this fault, but its presence is inferred from the fact that Lake Timiskaming follows a narrow, deep depression for its entire length. The most important evidence, however, occurs at the north end of the lake, where the fault cuts across Paleozoic limestones and shales, and the outcrop of the fault has been observed in at least one place. These Paleozoic sediments have been carried down on the east side of the fault 800 to 1,000 feet, according to G. S. Hume (Fig. 9).

The best description of the fault has been given by G. S. Hume,[2] and owing to its importance as a major fault of the region, a part of Hume's description is given below. The average reader may not have access to the technical journal in which Mr. Hume's paper was published.

> A study of the Paleozoic rocks has revealed the presence of a fault which is responsible for the straight western shore of Lake Timiskaming, and a fault-line scarp extending about eighteen miles northwest from the head of the lake. The thickness of the various [Paleozoic] formations included along the fault shows the displacement to be from 800 to 1,000 feet, with the downthrow side to the east. The rocks on the eastern side of the fault are Silurian, with a westward dip,

---

[1] Ont. Bur. Mines, Vol. XIX, pt. II, pp. 119-120.
[2] Am. Jour. Sci., 4th. ser., 1920, Vol. 50, pp. 293-309.

and near the fault at New Liskeard station a well boring has shown that they are covered with post-glacial deposits over 240 feet thick. At an elevation of over 250 feet higher, on the west side of the fault, Ordovician occurs in flat-lying beds, while on the fault-line scarp itself, Silurian strata outcrop at various places, with beds tilted over 50 degrees to the east. North of the lake, at a higher elevation, pre-Cambrian rocks outcrop to the west of the fault-line, while Silurian occurs to the east, so that the faulting relationships are quite evident. The scarp decreases in elevation to the north, due to the irregularities of the surface having been completely obliterated by the later deposits of post-glacial clay.

Regarding the age of the Lake Timiskaming fault, Hume remarks:—

> Since the Silurian rocks have been broken by the faulting, and glacial and post-glacial material are undisturbed, it is obvious that the faulting is post-Silurian and pre-glacial. The presence of a fault-line scarp, now over 150 feet high, which was over 400 feet high before the depression at its base was partly filled with post-glacial clay, is in favour of a date for faulting much nearer the Pleistocene than the Silurian. The fault-scarp is relatively slightly dissected by stream action, so that it is believed it could not have been earlier than the Cenozoic, and the probability is that it is late Tertiary, perhaps connected with the widespread crustal instability and accompanying earth movements which took place in Pliocene time.

It may be added that there are faults in the Cobalt silver area which are not only pre-Cambrian in age, but which are earlier than the Cobalt series. In a fault with such a great displacement as that of the Lake Timiskaming fault it is possible that movement began in pre-Cambrian times, and continued at intervals during Paleozoic or later eras.

Relation of Faults to Veins

Faulting in the pre-Cambrian rocks, as mining operations have now proved, is widespread and complex. The great antiquity of the formations, and the profound disturbances to which, at various times, they have been subjected, show that faulting was not confined to any one period in this great era, but that it must, indeed, have taken place from its most remote times down to its most recent.

To its most recent period, the Keweenawan, belongs the formation of the silver veins.

A little reflection will, therefore, show that when the veins were formed, most of the faults and fractures had already been developed. So that when the silver-bearing solutions began to circulate through the crust of the earth, the solutions found many possible channels through which they could permeate.

Some of these channels offered an easy path of circulation; others were more or less impermeable. Solutions moving through easy paths of circulation would meet with impermeable faults which would stop or impede circulation at certain points and thus confine the formation of ore-shoots within restricted areas.

Curiously enough, these silver-bearing solutions did not choose, as a general rule, the great faults in which to deposit their precious burden. The solutions chose, for the most part, the joint planes and minor fractures. One may wonder why such is the case; why, for instance, more ore was not deposited in such a great fracture as the Cobalt lake fault which has a displacement of more than 500 feet at the McKinley-Darragh mine.

The explanation appears to be that the minor fractures offered easier channels along which the solutions could permeate. Possibly the soft, clayey material in the faults made it difficult for circulation to take place.

While it is true that most of the ore is confined to joint planes and minor fractures, very productive ore-shoots have been found, as already pointed out, in such important faults as Wood's fault in South Lorrain and fault No. 64 on the Nipissing.

Although the above general principles regarding the relations between faults and veins appear simple enough, the practical working out of these relations presents one of the difficult problems in the geology of Cobalt and South Lorrain. Much unpublished discussion regarding the subject has taken place.

The writer believes that most of the important faults are older than the veins. In some cases, however, movement has taken place after the deposition of the ore.

The age relation of some of the faults to the veins is clear. If we consider, for example, three of the faults, namely, the Cobalt lake fault, fault No. 64 on the Nipissing, and fault X on the Townsite, it will be found that vein material in these faults is younger than the faults. The proof that the vein material is younger is found in the fact that high-grade ore occurs in these faults. That is to say, the ore abuts against the gouge of the faults. And as the movement in the fault took place along the gouge, it is evident that a vein cannot be said to be more actually in a fault than when it rests against the gouge.

A different variety of evidence may be given to show that some of the silver veins are younger than faults. This evidence is found at vein No. 490 at the east side of the Nipissing property north of Cobalt lake. The vein cuts through a fault, known as the "valley" fault, which has a reverse displacement of about 75 feet. The vein is not displaced by this fault and must consequently be younger than the fault (Fig. 15).

Again on the City of Cobalt property, vein No. 32 passes through a fault known as the "west" fault and the vein shows little or no displacement.

The "galena" fault on the Buffalo has, in places, a vein of high-grade ore in it, and this vein is therefore younger than the fault.

The "main" vein of La Rose property extends vertically downward into the Cobalt lake fault and is evidently a branch fracture of that fault.

In South Lorrain, Wood's vein and other important veins occur in faults.

It may be remarked here that there appears to have been some later movement in the Cobalt lake fault after the ore was deposited in it. This later movement is shown by the fact that a smaltite vein in the fault at the Princess mine is crushed in places into roundish balls, and these roundish balls are much slickensided. However, this crushing of veins in faults is rare. In the case of the Cobalt lake fault, the extent of the later movement is not known, but judging from the general absence of marked crushing or brecciation of the vein it is likely that the later movement is not of importance.

When we consider, however, the Lake Timiskaming fault, the amount of this later movement was great—probably 800 to 1,000 feet. This later movement took place in Paleozoic times.

Character of Vein-Filling in Faults

It has been shown that most of the faults in Cobalt and South Lorrain are older than the productive silver-bearing veins.

The character of the vein-filling in these faults is sometimes quite different from that in the veins which occupy joint planes. The minerals which are found in small quantities in the faults are: galena, zinc blende, copper pyrites, iron pyrites, marcasite, and quartz, together with pink and white calcite.

It would appear that this kind of vein-filling, namely, galena, zinc blende, iron pyrites, and so forth, belongs to a period of deposition preceding the deposition of the silver ores and cobalt and nickel arsenides.

The older period is characterized by the deposition of sulphides, the younger period by the deposition of arsenides and native silver.

Influence of "Iron Formation" and Lamprophyre Dikes in Formation of Vein Fractures

In a number of cases it has been found that veins in the Cobalt series when traced downwards into the underlying Keewatin pass into steeply dipping beds of slate and chert which have been called "iron formation." When these veins are followed into this formation it has been found in certain cases that they conform approximately in strike and dip with the "iron formation." From this evidence it would appear that the production of some of the joints or fissures in the overlying Cobalt series was guided by the structure of the Keewatin "iron formation" below the Cobalt series.

Miller has already pointed out that certain veins in the Keewatin follow the path of lamprophyre dikes.[1]

Ore Reserves and Sampling

As this report was made for the purpose of working out the underground structure of the rocks, no attempt was made to estimate the ore reserves now remaining in the mines. This would have been a task quite beyond the scope of the report. Very little sampling was done by us during our examination. The annual reports of some of the mining companies generally give an estimate of the ore reserves at the respective properties.

Since the discovery of silver at Cobalt in 1903, shipments from the camp and outlying silver areas have been as follows:—

TOTAL SHIPMENTS OF SILVER FROM ENTIRE COBALT AREA, 1904-1923

Year	Average price, cents per ounce (New York)	Silver shipments in Troy ounces, 1904-1923					
		Total ounces	Cobalt	Casey township[3]	South Lorrain[4]	Gowganda[4]	Montreal River and Maple Mountain
1904	57.221	206,875	206,875	....	....	....	....
1905	60.352	2,451,356	2,451,356	....	....	....	....
1906	66.791	5,401,766	5,401,766	....	....	....	....
1907	65.237	10,023,311	10,023,311	....	....	....	....
1908	52.864	19,437,875	19,424,251	500	13,124	....	....
1909	51.502	25,897,825	25,658,683	26,185	194,955	....	18,002
1910	53.486	30,645,181	29,849,981	92,544	221,133	471,688	9,835
1911	53.340	31,507,791	29,989,893	114,789	933,912	468,687	510
1912	60.835	30,243,859	28,605,940	253,824	834,119	549,976	....
1913	57.791	29,681,975	28,105,505	825,108	248,992	502,370	....
1914	54.811	25,162,841	24,155,699	499,643	108,199	399,300	....
1915	49.684	24,746,534	24,280,366	223,939	....	242,229	....
1916	65.661	19,915,090	19,008,517	445,900	77,280	383,393	....
1917	81.417	19,401,893	18,327,258	....	10,000	1,064,635	....
1918	96.772	17,661,694	16,807,407	143,901	72,188	638,198	....
1919	111.122	11,214,317	10,314,689	171,278	4,586	723,764	....
1920	100.900	10,845,436	10,402,249	....	8,253	433,352	1,582
1921	62.654	8,261,931	7,673,535	1,101	328,886	258,292	117
1922	67.521	10,695,133	9,239,147	1,028	1,284,307	170,651	....
	Total...	333,402,683	319,926,428	2,799,740	4,339,934	6,306,535	30,046
1923[2]	64.873	10,493,097	7,375,469	....	2,955,646	160,761	1,221

---

[1] Ont. Bur. Mines, Vol. XIX, pt. II, p. 71.

[2] Preliminary figures.

[3] The entire production from Casey township was obtained by the Casey-Cobalt Silver Mining Company. In the year 1919, the Casey-Kismet Mining Company (northeast ¼, north ½, lot 5, concession VI, Harris township) shipped 28,432 ounces, and the Harris Consolidated Mines, Limited (southeast ¼, south ½, lot 6, concession I, Casey township) shipped 47,570 ounces. Both of these were operated by the Casey-Cobalt Silver Mining Company, and these shipments were included by the Casey-Cobalt Silver Mining Company for the year 1919.

[4] Details of shipments from South Lorrain and Gowganda are given on pages 192 and 28, respectively.

TABLE SHOWING PRODUCTION OF SILVER MINES, 1904 to 1922

Year	No. of producing mines	Shipments and silver contents								
		Ore			Concentrates and residues			Bullion	Total	
		Tons	Ounces	Av. per ton, oz.	Tons	Ounces	Av. per ton, oz.	Ounces	Ounces	Value
										$
1904	4	158	206,875	1,309	......	....	.....	....	206,875	111,887
1905	16	2,144	2,451,356	1,143	......	....	.....	....	2,451,356	1,360,503
1906	17	5,335	5,401,766	1,013	......	....	.....	....	5,401,766	3,667,551
1907	28	14,788	10,023,311	677	......	....	.....	....	10,023,311	6,155,391
1908	30	24,487	18,022,480	736	1,137	1,415,395	1,244	....	19,437,875	9,133,378
1909	31	27,729	22,436,355	809	2,948	3,461,470	1,174	....	25,897,825	12,461,576
1910	41	27,437	22,581,714	821	6,845	7,082,834	1,030	980,633	30,645,181	15,478,047
1911	34	17,278	20,318,626	1,176	9,375	8,056,189	858	3,132,976	31,507,791	15,953,847
1912	30	10,719	15,395,504	1,436	11,214	9,768,228	871	5,080,127	30,243,859	17,408,935
1913	35	9,861	13,668,079	1,386	11,016	8,489,321	770	7,524,575	29,681,975	16,553,981
1914	32	4,302	6,504,753	1,511	12,152	8,915,958	733	9,742,130	25,162,841	12,765,461
1915	24	2,865	6,758,286	2,359	11,996	10,001,548	834	7,986,700	24,746,534	12,135,816
1916	28	2,177	4,672,500	2,146	8,561	7,598,011	887	7,644,579	19,915,090	12,643,175
1917	28	2,288	3,271,353	1,429	13,720	6,445,243	469	8,053,318	19,401,893	16,121,013
1918	38	1,456	1,401,050	962	17,958	5,793,756	323	10,466,888	17,661,694	17,341,790
1919	33	850	806,341	949	15,208	4,024,212	265	6,383,764	11,214,317	12,738,994
1920	35	578	668,081	1,152	9,757	3,777,812	387	6,402,423	10,846,321	10,654,471
1921	28	948	986,597	1,041	3,101	2,962,771	955	4,312,603	8,261,931	5,564,594
1922	22	1,485	1,712,878	1,154	7,897	1,675,055	212	7,323,194	10,711,127	7,658,802
Total.....		156885	157,285,905	1,002	142885	89,477,803	626	85,033,910	333,419,562	205,909,212

The greatest yield of silver in the Cobalt area was achieved in 1911, when 31,507,791 ounces were shipped. There were 34 producing mines, counting as one mine all the properties owned by the same company or firm. The largest shippers were the following:—

TABLE SHOWING SILVER PRODUCTION IN 1911

COMPANY	TROY OUNCES SHIPPED
Nipissing	4,627,043
La Rose	4,090,156
Crown Reserve	3,430,902
Coniagas	3,273,465
McKinley-Darragh-Savage	2,551,885
Kerr Lake	2,238,353
Buffalo	1,644,245
O'Brien	1,397,546
Temiskaming	1,162,317
Hudson Bay	1,067,667
Wettlaufer-Lorrain	925,017
Beaver	888,876
Cobalt Townsite	834,949
Trethewey	716,464
Cobalt Lake	626,044
Miller Lake-O'Brien	338,000
Right of Way	289,718

DIVIDENDS AND BONUSES PAID BY SILVER MINING COMPANIES TO DECEMBER 31ST, 1922

Name of company	Date of incorporation	Authorized capital	Capital stock issued	Par value per share	Amount of dividends and bonuses paid to end of 1921	Amount of dividends and bonuses paid during 1922	Total of dividends and bonuses paid to Dec. 31, 1922	Date when last dividend or bonus paid
Aladdin Cobalt Company, Ltd.	Aug. 23, 1912	$500,000	$500,000	$5.00	$75,000.00	....	$75,000.00	Apr. 30, 1917
Beaver Consolidated Mines, Ltd.	Mar. 1, 1907	2,000,000	2,000,000	1.00	710,000.00	....	710,000.00	May 31, 1920
Buffalo Mines, Ltd.[1]	Apr. 27, 1906	500,000	500,000	.50	2,787,000.00	....	2,787,000.00	May 28, 1914
Casey Cobalt Silver Mining Co., Ltd.	Dec. 19, 1906	100,000	100,000	1.00	203,249.33	....	203,249.33	Apr. 22, 1914
Cobalt Central Mines Co., Ltd	Dec. 13, 1905	5,000,000	5,000,000	1.00	192,845.00	....	192,845.00	Aug. 25, 1909
Cobalt Comet Mines, Ltd.[2]	Apr. 16, 1913	1,000,000	1,000,000	1.00	230,000.00	....	230,000.00	Apr. 1, 1915
Cobalt Silver Queen, Ltd	Apr. 1, 1906	1,500,000	1,500,000	1.00	315,000.00	....	315,000.00	Dec. 31, 1908
Coniagas Mines, Ltd.	Nov. 24, 1906	4,000,000	4,000,000	5.00	10,940,000.00	$200,000.00	11,140,000.00	Nov. 1, 1922
Crown Reserve Mining Co., Ltd.	Jan. 16, 1907	2,000,000	1,999,957	1.00	6,190,849.00	....	6,190,849.00	Dec. 28, 1916
Foster Cobalt Mining Co., Ltd	Feb. 14, 1906	1,000,000	915,588	1.00	45,000.00	....	45,000.00	Jan. 1, 1907
Hudson Bay Mines, Ltd.	July 16, 1909	3,500,000	3,200,050	5.00	778,909.42	....	778,909.42	Aug. 31, 1913
Kerr Lake Mining Company, Ltd.	Aug. 9, 1905	40,000	40,000	100.00	9,475,000.00	380,000.00	9,855,000.00	Oct. 13, 1922
La Rose Mines, Ltd.	May 31, 1908	1,500,000	1,500,000	1.00	7,505,409.56	150,000.00	7,655,409.56	Apr. 20, 1922
McKinley-Darragh-Savage Mines of Cobalt, Ltd.	Apr. 27, 1906	2,500,000	2,247,692	1.00	5,955,391.86	....	5,955,391.86	Oct. 1, 1920
Mining Corporation of Canada, Ltd.[3]	Nov. 23, 1916	8,300,250	8,300,250	5.00	5,498,874.97	....	5,498,874.97	Sept. 15, 1920
City of Cobalt Mining Co., Ltd.[4]	Oct. 5, 1906 Jan. 7, 1909	500,000 1,500,000	1,500,000	1.00	145,000.00	....	145,000.00	Apr. 15, 1920
Cobalt Lake Mining Co., Ltd.[4]	Dec. 22, 1906	3,000,000	3,000,000	1.00	465,000.00	....	465,000.00	May 29, 1914
Cobalt Townsite Mining Co., Ltd.[4]	May 8, 1906	100,000	45,011	1.00	1,042,259.61	....	1,042,259.61	Nov. 11, 1914

Nipissing Mining Co., Ltd.[5]	Dec. 16, 1904	250,000	250,000	100.00	24,293,297.25	1,120,000.00	25,413,297.25	Oct. 20, 1922
Penn-Canadian Mines, Ltd.[6]	Apr. 24, 1912	1,500,000	1,349,705	1.00	175,461.65		175,461.65	Sept. 10, 1917
Peterson Lake Silver-Cobalt Mining Co., Ltd.	Apr. 11, 1906	3,000,000	2,469,802	1.00	462,350.35		462,350.35	Jan. 2, 1917
Right of Way Mining Co., Ltd.	July 13, 1906	500,000	499,518	1.00	324,643.93		324,643.93	Oct. 1, 1909
Right of Way Mines, Ltd.	Sept. 11, 1909	2,000,000	1,685,500	1.00	252,825.00		252,825.00	Mar. 17, 1917
Seneca-Superior Silver Mines, Ltd.	Sept. 29, 1911	500,000	478,884	1.00	1,579,817.20		1,579,817.20	Dec. 15, 1916
Temiskaming Mining Co., Ltd.	Nov. 5, 1906	2,500,000	2,500,000	1.00	2,159,156.25		2,159,156.25	Jan. 31, 1920
Temiskaming and Hudson Bay Mining Co., Ltd.	July 10, 1903	25,000	7,761	1.00	1,940,250.00		1,940,250.00	Nov. 10, 1914
Trethewey Silver Cobalt Mines, Ltd.	May 30, 1906 June 1, 1911	2,000,000	1,000,000	1.00	1,211,998.50		1,211,998.50	Jan. 2, 1919
Wettlaufer Lorrain Silver Mines, Ltd.	Nov. 30, 1908	1,500,000	1,416,590	1.00	637,465.50		637,465.50	Sept. 22, 1913
Total					$85,592,054.38	$1,850,000.00	$87,442,054.38	

---

[1] In 1917 the capital stock of the company was reduced from $1,000,000 to $750,000, in 1918 from $750,000 to $500,000, and on December 21, 1919, from $500,000 to $150,000, by returning to shareholders amounts equal to the reduction in capital, leaving 300,000 shares issued of 50 cents each. The mine was sold to the Mining Corporation of Canada, and operated by it in 1920 and subsequently.

[2] Cash assets amounting to $50,000 paid on April 27, 1917.

[3] Mining Corporation of Canada, Limited, owns and operates the City of Cobalt, Cobalt Lake, and Cobalt Townsite mines.

[4] Now owned and operated by Mining Corporation of Canada, Limited.

[5] Includes $16,288,297.25 paid in dividends by the Nipissing Mines Co. (the holding company) to the end of 1916.

[6] Paid out of capital $40,491.15 on Sept. 10, 1917, and an equal amount on April 24, 1918.

GOVERNMENT REVENUE AND SILVER PRODUCTION

The silver mines of the entire Cobalt area have paid in royalties to the Ontario Government the sum of $2,067,153, to October 31st, 1923.

The following table gives the amounts paid by various companies. These royalties have nothing to do with the taxes. Every company which is making a sufficient profit is subject to taxes. Only companies which bought or leased certain lands under special agreement from the Ontario Government are subject to the payment of royalties.

Royalties to October 31st, 1923, paid to the T. & N. O. Railway Commission, as set forth in their annual reports, amounted to $1,059,440.31. This is in addition to the figures given in the table below:—

TABLE SHOWING ROYALTIES RECEIVED BY THE ONTARIO GOVERNMENT

Mine	Royalty
O'Brien	$884,322 82
Crown Reserve	812,410.91
Hudson Bay	333,870.05
Chambers-Ferland	26,259.64
Provincial	6,735.14
Hargrave	1,200.00
Wyandoh	1,421.72
Waldman	932.72
Total	$2,067,153.00

Royalty agreements have terminated, and producing mines now pay a Profit Tax under the provisions of the Mining Tax Act.

The Ontario Government received $1,532,162.51 as Profit Tax from the silver mines to October 31st, 1923, the end of the fiscal year.

In the matter of the sale of Cobalt lake, Kerr lake, and lots in the Gillies limit, the Government received $1,640,139.11, distributed as follows:—

Cobalt lake (1907)	$936,500.00
Kerr lake (1907)	178,500.00
[1]Gillies limit lots (1908-10), including Provincial mine ore sales and property sale (surplus receipts over expenditure)	527,523.64
Total	$1,642,523.64

---

[1] The gross revenue was $836,886.63.

SILVER PRODUCTION FROM THE COBALT AREA PROPER[1]—TROY OUNCES SHIPPED

Year	Nipissing	Cobalt Lake	Cobalt Townsite	City of Cobalt	Mining Corporation	Coniagas	Kerr Lake	La Rose[2]	Crown Reserve	McKinley-Darragh-Savage
1904	32	...	...	...	...	...	...	112,500	...	7,873
1905	753,154	...	...	...	...	130,853	128,805	311,847	...	235,262
1906	2,214,822	...	...	...	...	567,009	425,000	880,100	...	42,354
1907	2,239,552	...	60,963	65,950	...	1,369,005	676,000	771,473	...	611,798
1908	2,893,031	74,934	108,827	503,772	...	1,369,995	1,551,324	1,759,479	1,698,955	667,970
1909	4,646,869	46,732	...	432,959	...	1,416,731	3,112,067	3,185,051	4,034,325	1,324,372
1910	5,596,136	239,728	195,597	305,216	...	2,621,681	2,877,299	2,769,266	3,248,196	2,606,891
1911	4,678,074	626,044	834,949	214,876	...	3,273,465	2,238,353	4,090,156	3,430,902	2,551,885
1912	4,719,578	1,123,146	1,505,396	207,951	...	3,703,942	1,895,309	2,920,344	2,714,765	2,694,560
1913	4,844,169	980,858	2,314,602	100,158	...	3,252,566	2,072,407	2,592,775	1,776,678	2,228,832
		3,091,442	5,020,334	1,830,752	9,942,528					
			Townsite-City							
			3,079,275							
1914	3,999,863	1,247,677	2,776,589		4,326,952	2,459,007	1,817,087	1,398,404	1,425,320	1,260,046
1915	4,623,958	1,566,206	3,115,638		4,342,795	1,916,616	2,109,355	1,071,694	512,396	1,061,827
1916	3,819,768	994,608			4,110,246	1,816,287	2,527,062	830,707	262,470	1,055,959
			8,971,502							
1917	3,798,802	...			4,546,065	1,273,853	2,302,466	478,639	309,420	1,013,602
1918	4,116,077	...		See	1,994,061	1,006,104	2,221,811	276,130	301,507	885,530
1919	3,080,070	...		description	1,088,064	918,063	802,243	290,227	265,853	760,787
1920	2,814,852	...		of City of	[3]1,815,594	990,176	610,604	492,801	65,232	613,428
1921	3,016,760	...		Cobalt	911,899	1,301,860	78,391	658,423	1,121	82,189
1922	3,845,012	...		mine	1,184,652	1,899,571	...	434,560	16,959	254,308
Total	65,700,579	6,899,933	15,822,588		34,262,856	31,286,744	27,445,583	25,324,576	20,064,099	19,959,473

[1] Shipment figures below do not necessarily agree with production figures as published in annual reports of the operating companies.
[2] La Rose, Lawson, Violet, University, Princess; for production of these mines see description under La Rose.
[3] Includes Buffalo.

SILVER PRODUCTION FROM THE COBALT AREA PROPER—TROY OUNCES SHIPPED—*Continued*

Year	O'Brien	Buffalo	Temiskaming	Trethewey	Hudson Bay[1]	Beaver	Seneca-Superior (Peterson Lake Lease)	Standard (Cobalt-Central) Penn-Canadian	Drummond (Cobalt Comet)[2]	Right of Way
1904	....	....	....	55,320	....	....	....	....	....	....
1905	117,055	82,068	....	345,602	63,020	....	....	....	Drummond 26,400	....
1906	145,012	210,598	....	127,848	7,620	....	....	....	287,348	86,349
1907	1,584,920	466,969	327,527	362,456	257,370	....	....	Standard 22,341	256,626	216,801
1908	1,765,073	903,126	1,013,874	717,183	1,116,387	....	....	468,138	718,793	447,585
1909	1,576,411	1,272,649	616,312	727,237	914,165	139,108	....	438,755	74,960	773,162
1910	1,162,303	1,629,327	1,994,226	846,579	663,236	182,036	....	149,282	120,573	455,986
1911	1,397,546	1,644,245	1,162,317	716,464	1,067,667	888,876	....	10,732	146,625	289,718
1912	1,091,631	1,890,150	1,217,994	620,923	692,817	607,551	320,575	92,076	232,348	59,973
1913	1,240,931	1,752,199	768,939	599,036	544,823	726,801	1,124,577	Penn-Canadian 334,426	Cobalt Comet 384,945	99,401
1914	1,231,834	912,350	323,022	543,097	380,792	692,095	1,409,766	556,119	712,892	122,227
1915	991,084	957,831	1,486,400	126,010	....	970,168	1,996,256	590,170	507,366	102,274
1916	776,068	267,468	873,507	190,988	50,268	567,993	676,422	518,585	185,504	122,928
1917	1,064,335	645,915	887,122	311,324	277,091	462,723	....	259,784	32,128	110,963
1918	1,074,312	870,247	517,763	291,269	122,953	411,606	....	222,198	20,629	49,723
1919	648,501	577,811	194,270	181,078	92,904	263,388	....	88,671	....	5,819
1920	1,179,706	..........[3]	298,627	48,373	80,555	228,602	....	....	....	18,444
1921	1,366,686	....	....	33,952	22,278	30,057	....	1,333	....	....
1922	896,195	....	....	..........[4]	....	3,715	....	....	....	....
Total	18,342,603	14,082,953	11,681,900	6,844,739	6,611,316	6,174,719	5,527,596	3,752,610	3,707,137	2,961,353

[1] Name of company changed from Temiskaming and Hudson Bay in 1909.
[2] In 1913 the Drummond Mines Company produced 136,133 ounces and Cobalt Comet 248,812 ounces.
[3] Included with Mining Corporation of Canada.
[4] Included with Coniagas.

SILVER PRODUCTION FROM THE COBALT AREA PROPER—TROY OUNCES SHIPPED—*Continued*

Year	Cobalt Silver Queen	Chambers-Ferland	Aladdin Cobalt	Dominion Reduction Co. (Dominion Mine)	Foster	Nova Scotia	Peterson Lake	King Edward (National)	Har-grave	Silver Leaf	Silver Cliff	Colonial
1904		Cobalt ore										
1905					110,000			Watts–3,160	12,056			
1906	195,807				64,450	10,785				900		
1907	182,987				209,000	112,000		King Edward 62,255		51,121		17,219
1908	589,693	69,477			99,500	110,136	55,081	253,196		343,112	70,267	359
1909	145,210	214,755				157,222	120,367	128,539			115,879	
1910	2,091	335,853				271,981	249,491	91,474	168,841	7,371	143,921	61,336
1911		94,030				145,694	134,653		147,114		49,755	192,159
1912		119,203							56,330			91,603
1913		69,467	22,792				31,253		32,232			23,445
1914		205,025	59,856		7,145		23,639					
1915	36,545		200,912							84,000		
1916			175,235						6,541			
1917	Several Lessees 3,679		330,063	88,488				National 55,126	57,392			
1918	20,450		198,927	45,318	7,700		19,008	59,963	15,884			
1919	22,373		20,375	707,817	137,463		35,755		3,474			
1920	14,600		21,467	20,569	178,282		75,096		7,108			1,883
1921	2,058		38,031	83,932	1,804					1,461	1,590	647
1922	9,618			27,237							22,668	
Total	1,225,111	1,107,810	1,067,658	973,361	815,346	807,818	744,343	653,713	506,972	487,956	404,080	388,681

SILVER PRODUCTION FROM THE COBALT AREA PROPER—TROY OUNCES SHIPPED—*Continued*

Year	Drummond Fraction	Bailey	Provincial	University (La Rose)	Green-Meehan and Red Rock	Cart Lake	Nancy-Helen	Little Nipissing	Mercer	Reliance	Angus, D. H. (Nip. Red Co. Mill clean-up)
1904											
1905				26,110							
1906				149,200							
1907				24,245	77,996		20,000				
1908			19,041				31,569				
1909				9,317			37,106	4,138			
1910			18,410					78,970			
1911			124,381		10,268		3,095				
1912		48,335	15,686		2,560						
1913		131,431									
1914	144,631	15,080				99,700					
1915	104,450			19,482							
1916	40,450					See Seneca-Superior			81,998		
1917	67,112		7,000	See University Mine							13,182
1918			11,634		74,066					3,636	22,040
1919			20,214		17,025					21,425	10,563
1920		8,401	29,466		44,274					20,671	
1921		67,706								675	
1922		15,647								659	
Total	356,643	286,600	245,832	228,354	223,629	99,700	91,770	83,108	81,998	47,066	45,785

SILVER PRODUCTION FROM THE COBALT AREA PROPER—Troy Ounces Shipped—*Continued*

Year	Glen Lake	Argentum	Waldman	Cochrane	Wyandoh	Adanac	Silver Bar	Lumsden	York-Ontario	Rochester Cobalt	Ruby	North Cobalt
1904												
1905												
1906												
1907												
1908												
1909		33,055										1,453
1910		561	28,858		26,651					11,696		
1911					2,586							
1912												
1913				3,272			21,981	18,129	17,198			
1914				29,750								
1915												
1916	42,605									1,763		
1917						2,620						
1918			165			427		2,026				
1919			4,384			25,010						
1920											8,702	
1921								933				
1922												
Total	42,605	33,616	33,407	33,022	29,237	28,057	21,981	21,088	17,198	13,459	8,702	1,453

SHIPMENTS FROM GOWGANDA MINES, 1910-1922

Mine	Ore and Concentrates, Tonnage Shipped														Total silver, ounces	Total cobalt paid for, lbs.
	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	Total tons		
Bartlett Crews-McFarlan	*	.....	.....	.....	.....	.....	.....	.....	30.20	42.00	.....	.....	.....	72.20	20219	.....
Bonsall	3.79	.....	.....	.....	.....	.....	.....	.....	.....	.....	13.06	.....	.....	16.85	10046	101
Boyd Gordon	27.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	27.00	4678	.....
Burk-Remey	1.80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.8	.....	.....
Calcite Lake	.....	*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Canadian Gowganda	.....	*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Castle-Trethewey	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	45.31	29.88	10.87	86.06	122423	1530
Everett	*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Kell	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.79	.....	.....	0.79	1621	254
Mann	.....	.....	13.74	15.87	18.00	.....	.....	.....	.....	.....	.....	.....	.....	47.61	97792	.....
Millerett	347.00	128.0	192.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	667.00	611822	5000
Miller Lake O'Brien	31.00	141.5	112.60	166.90	113.90	109.66	170.57	350.00	160.40	189.79	115.09	103.07	75.80	1840.28	5348350	145730
Powerful	*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Reeve-Dobie	54.00	.....	.....	.....	.....	.....	11.00	5.75	.....	1.94	10.44	.....	.....	83.13	88584	.....
Welch	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.00	1000	.....
TOTALS																
Ore and Conc. ....tons	465.59	269.5	318.34	182.79	131.90	109.66	181.57	355.75	190.60	233.73	184.69	132.95	86.67	2844.74	.....	.....
Silver ....ounces	471688	468687	549976	502370	399300	242229	383393	1064635	638198	723764	433352	258292	170651	.....	6306535	.....
Cobalt (paid for) ....lbs.	8432	.....	.....	.....	.....	.....	.....	56884	26994	27404	15236	9187	8478	.....	.....	152615

*In addition to the shipments reported to the Department of Mines and shown in the table of production, A. A. Cole's reports for the Temiskaming and Northern Ontario Railway Commission show the following additional shipments:—

1909—Bartlett, 2 tons.
1910—Everett, 8.35 tons; Powerful, 1 ton.
1911—Calcite Lake, 8.5 tons; Canadian Gowganda, 8 tons.

Note:—Shipments of about 6½ tons have been reported in addition from the Hudson Bay properties in Leith township. The silver contents of the Burk-Remey shipment were never reported to the Department.

Silver Production from Important Localities in the World Compared

A comparison of the silver yield of the entire Cobalt area with the yield of other great silver camps of the world, shows that Cobalt has been the fourth largest producer of silver. The following table has been compiled largely from information obtained from a text-book by Beyschlag, Vogt, and Krusch.

COBALT'S SILVER PRODUCTION COMPARED WITH THAT OF OTHER DISTRICTS[1]

Locality	Silver Production (metric tons)	Years
Potosi, Bolivia	30,000	Since 1545
Guanajuato, Mexico	15,000	Since 1558
Zacatecas, Mexico	14,000	1548–1832
Cobalt, Canada[2]	10,375	1904–1922
Freiberg, Germany	5,243	1163–1896
Comstock, Nevada	4,820	1859–1889
Pachuca, Mexico	3,500	1522–1901

WORLD'S AVERAGE ANNUAL PRODUCTION OF SILVER, 1493-1912[3]

Period	Average Annual Production (ounces)	Period	Average Annual Production (ounces)
1493-1544 (52 years)	2,152,070	1821-1860 (40 years)	21,966,300
1545-1600 (56 years)	11,111,040	1861-1869 (9 years)	38,800,000[4]
1601-1700 (100 years)	11,970,730	1870-1887 (18 years)	74,502,470
1701-1800 (100 years)	18,336,720	1888-1907 (20 years)	158,037,350
1801-1820 (20 years)	23,066,340	1908-1912 (5 years)	217,499,950

WORLD'S ANNUAL PRODUCTION OF SILVER, 1901-1921[5]

Year	Fine Ounces	Year	Fine Ounces
1901	173,011,283	1912	226,251,013
1902	162,763,483	1913	225,410,085
1903	167,689,322	1914	168,452,942
1904	164,195,266	1915	184,204,745
1905	172,317,688	1916	168,843,000
1906	165,054,497	1917	174,187,800
1907	184,206,984	1918	197,394,900
1908	203,131,404	1919	174,517,400
1909	210,453,431	1920	174,212,686
1910	222,879,362	1921	171,285,542[6]
1911	225,372,844	1922	213,541,784[7]

YEARLY AVERAGE PRICE OF SILVER, 1895-1923, NEW YORK[7]

Year	Price per Ounce cents	Year	Price per Ounce cents
1895	65.250	1910	53.486
1896	67.060	1911	53.340
1897	59.790	1912	60.835
1898	58.260	1913	59.791
1899	59.580	1914	54.811
1900	61.330	1915	49.684
1901	58.950	1916	65.661
1902	52.160	1917	81.417
1903	53.570	1918	96.772
1904	57.221	1919	111.122
1905	60.352	1920	100.900
1906	66.791	1921	62.654
1907	65.237	1922	67.521
1908	52.864	1923	64.873
1909	51.502		

---

[1] "The Deposits of the Useful Minerals and Rocks," by Beyschlag, Vogt and Krusch, 1916, translated by S. J. Truscott, pp. 202, 529, 675.

[2] Shipments for 1922 added to those in the text book.

[3] Report on Silver, published by the Imperial Mineral Resources Bureau, 1923.

[4] The production for several years of this period is only approximately known.

[5] Eng. & Min. Jour.; and Report on Silver, published by Imperial Mineral Resources Bureau, 1923.

[6] Annual Report, 1923, Director of United States Mint.

[7] Eng. Min. Jour.-Press, Jan. 19, 1924, p. 140.

GENERAL GEOLOGY

A brief outline of the general geology will be given in order to make the report intelligible; and below will be found a legend showing the rock formations in northeastern Ontario, including the Cobalt silver area, the Sudbury nickel area, and the Porcupine and Kirkland lake gold areas.

LEGEND

(*After Willet G. Miller*)

PLEISTOCENE

Glacial drift, post-glacial clays, sands, gravels.

PALEOZOIC

Silurian and Ordovician

Limestone shales, sandstone, basal conglomerate.

GREAT UNCONFORMITY

EOZOIC OR PRE-CAMBRIAN

(Keweenawan)

Granite

INTRUSIVE CONTACT

Diabase dikes, Nipissing diabase sill at Cobalt, and norite at Sudbury.

INTRUSIVE CONTACT

Animikean

Upper Cobalt Series

Arkose and quartzite.

Lower Cobalt Series

Conglomerate, quartzite, greywacke.

GREAT UNCONFORMITY

(Matachewan)

Diabase dikes, etc.

(Algoman)

Granite, syenite, porphyry, etc.

(Haileyburian)

Lamprophyre, diabase, serpentine, etc.

INTRUSIVE CONTACT

Timiskamian

Conglomerate, quartzite, greywacke, slate.

GREAT UNCONFORMITY

(Laurentian)

Gneissoid granite, banded gneiss. Probably also includes much granite of later age.

INTRUSIVE CONTACT

Loganian

Grenville

Crystalline limestone, etc.

Jaspilite or "iron formation."

(Keewatin)

Green schists, amygdaloidal basalt, ellipsoidal basalt, andesite, acid porphyries, etc., essentially lava flows.

With the exception of a small outlier of fossiliferous rocks of Paleozoic age, the rocks belong entirely to the pre-Cambrian.

A description of the rocks which are more immediately associated with the silver ores will be found sufficient for the requirements of a report such as this.

The oldest series, known as the Keewatin, consists mainly of basaltic lava flows, interbedded with which are beds of "iron formation" consisting of slate, chert, and greywacké, the whole series of basalts and "iron formation" having been tilted up into vertical position.

The Timiskaming series of conglomerate, slate, greywacké, and quartzite was laid down on top of the Keewatin. These two series, the Keewatin and Timiskaming, have been intruded by many lamprophyre dikes of Haileyburian age. The dikes are, for the most part, two or three to fifteen or twenty feet in width.

All of the rocks mentioned in the preceding paragraph were then intruded by a great mass of pink granite of Algoman age.

A prolonged period of weathering and erosion then followed, and the rocks were planed down to a surface probably not much unlike the surface existing in northern Ontario at the present time.

On this ancient basement, rest the rocks of the Cobalt series. This series is of immense importance owing to the fact that most of the silver has been mined from veins in it. The Cobalt series consists of beds of fine and coarse boulder conglomerate, greywacké, slate-like greywacké, and quartzite. It has a thickness of about 600 feet at the north end of Cobalt lake.

The great geological event of most importance to the miner then took place. This consisted of the intrusion of an enormous sill of diabase about 1,000 feet thick. The sill has been named the Nipissing diabase and is of Keweenawan age. Its importance is due to the fact that the silver veins have been deposited from mineral solutions which were given off by it during the time it was cooling and for some time after it had solidified and had been faulted.

Dikes of diabase cut all of the rocks above described and also, apparently, the silver veins.

What is known as the Pleistocene epoch, or most recent time, was not a beneficent one in its relation to the ore deposits of northeastern Ontario. During this epoch a great sheet of ice known as the Labradorean sheet accumulated in Labrador. It spread out in all directions, part of it coming southward and southwestward, and sweeping the rocks clean of their weathered and decomposed surface. In doing so the upper parts of ore-bodies have been carried away and mixed with the glacial debris. Only in a few places, as at the Keeley silver mine in South Lorrain, has any remnant of this pre-glacial weathering been preserved in the Province of Ontario.

Structure of the Rocks

The structure of the rocks is illustrated in the coloured vertical section facing page 8. This section is drawn through the most productive part of the camp, passing as it does through, or in the vicinity of, the Coniagas, Trethewey, Nipissing, La Rose, and O'Brien mines.

The great extent of the underground work in this locality through which the cross-section passes has made it possible to show, with tolerable accuracy, the relation of the rocks, one to another, and to the veins and faults. The writer believes that if the reader will make a close study of this cross-section, he will gain a better idea of the structure of the rocks than could be acquired by perusing several pages of descriptive writing.

The structure of the Nipissing diabase sill, and its relation to the silver veins, is best studied at the Beaver and Temiskaming mines. There the entire sill has been preserved from erosion. This structure is illustrated in the coloured cross-section facing page 32. The reader is referred to this section if he would understand the structure in this part of the camp.

Folding

Some of the rocks in the Cobalt silver area have been greatly disturbed. The lava flows, for example, of the Keewatin series have been severely folded and are now found in vertical or almost vertical attitudes. Although these Keewatin lava flows have been strongly folded they have not been altered to schists such as are commonly found in the Porcupine gold area 107 miles northwest of Cobalt. The vertical attitude of the flows in Cobalt may be seen in the area between Cobalt and Sasaginaga lakes.

The sediments of the Timiskaming series are also steeply folded. These rocks are exposed along the shores of Lake Timiskaming between Haileybury and New Liskeard. They have been tilted up into vertical or nearly vertical attitudes.

The formations of most importance to the miner belong to the Cobalt series. They are not disturbed as much as the Keewatin or Timiskaming. The Cobalt series in places rests in almost horizontal attitudes. In other places the series dips at gentle to somewhat steep angles. In the area around Diabase mountain the slate-like greywacké of the Cobalt series is almost horizontal as is shown in the coloured cross-section facing page 40. But in the vicinity of the town of Cobalt the sediments of this series have been disturbed by the Cobalt lake and other faults shown in Fig. 8. The bed of Cobalt lake forms a decided syncline with the sediments dipping towards the long axis of the lake at angles from 10 degrees or 20 degrees to as high as 45 degrees or more in the vicinity of the Cobalt lake fault. The fault is shown in the coloured cross-section facing page 12.

Coming now to an important rock formation, namely, the Nipissing diabase sill, it is certain that some folding, particularly around Cobalt lake, took place in this great sheet of rock, the thickness of which is about 1,000 feet. The sill has been faulted by the Cobalt lake fault—exactly how much is not known; in the coloured cross-section facing page 8, an attempt has been made to estimate the amount of this displacement which was caused by the Cobalt lake fault. While it is thus evident that the sill was folded to a certain extent in the vicinity of the Cobalt lake fault, there are other places in the sill which show apparent, not real, sharp folding, such as in the Kerr lake area. The sill in this area forms a structure known as the Kerr lake dome. This is dealt with in the following paragraphs.

The Kerr Lake Diabase Dome

In the Kerr lake area the Nipissing diabase has the form of an elongated dome, known as the Kerr lake dome. This anticline-like structure is shown in the vertical section facing page 34. A study of the coloured section, which is drawn through the Crown Reserve mine, will convince one that folding did not cause the diabase to acquire its anticline-like structure. It will be noted that the sediments of the Cobalt series below the dome are resting at almost horizontal or gently dipping angles. Had the diabase sill been folded into a sharp anticline, the sediments of the Cobalt series immediately below would not only have been folded into an anticline, but also altered to schists. The same structure was

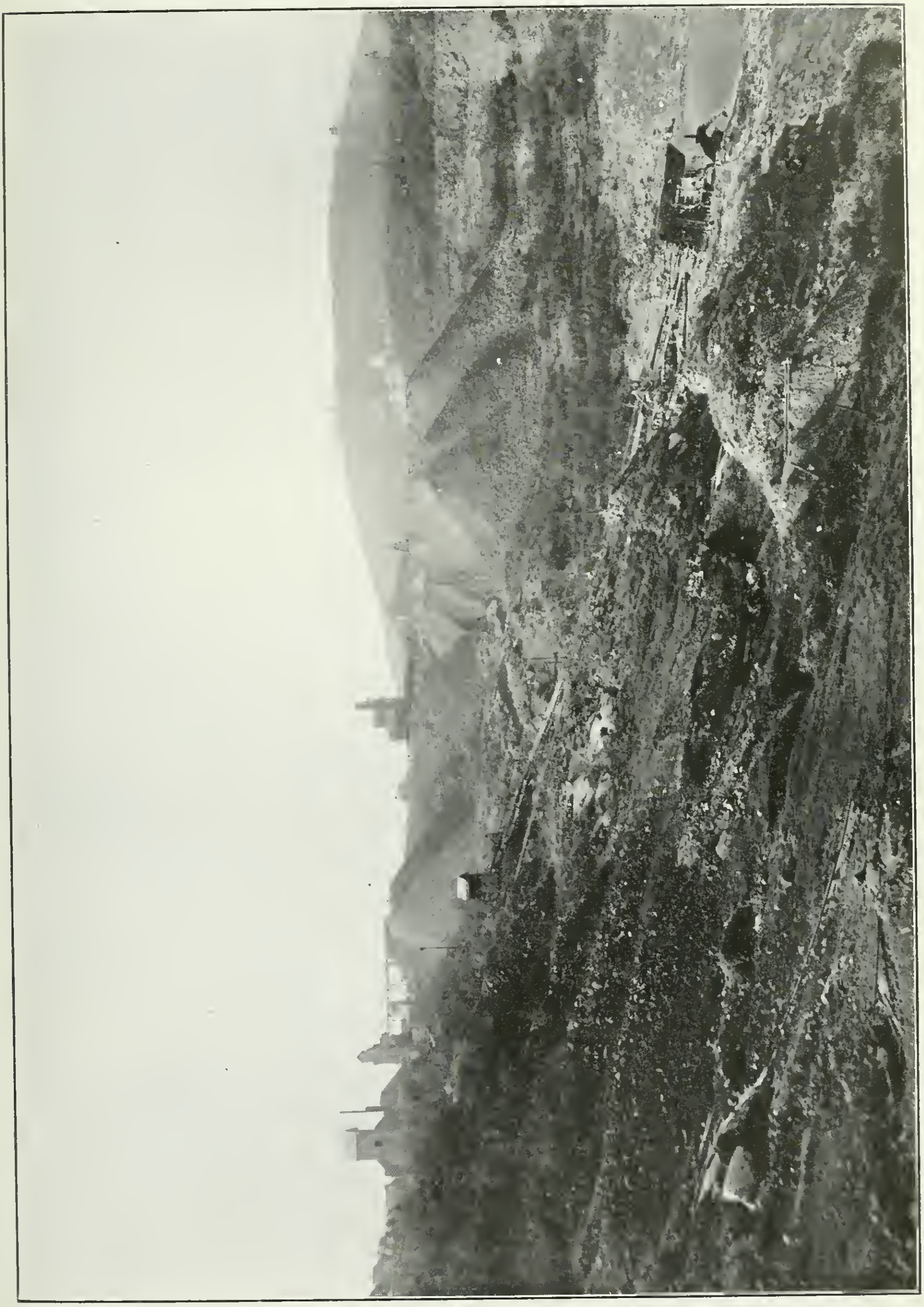


Fig. 10—Bed of Kerr lake after it was pumped out; Kerr Lake and Crown Reserve dumps; Diabase mountain in background.

found at the University mine at the west end of the dome. This structure is illustrated in the coloured section facing page 40. It will be noted that at the University the sediments of the Cobalt series below this dome are not folded into an anticline as they would be if the diabase sill had been folded into an anticline.

From the evidence found at the Crown Reserve and University mines it is probable that the diabase assumed its dome structure during the time it was intruded in a molten condition.

In South Lorrain a somewhat similar dome occurs in the diabase sill. This is discussed in the chapter dealing with South Lorrain.

Practically all of the silver-bearing veins in the Kerr lake area occur below the Kerr lake diabase dome. All of the productive veins, for example, in the University, Foster, Lawson, Crown Reserve, Kerr Lake, and Drummond have been found below this dome. The rocks below a similar diabase dome in South Lorrain have not, as yet, been productive of silver veins.

Thickness of Nipissing Diabase Sill

The thickness of the Nipissing diabase sill has now been definitely determined. It has been penetrated at four places, namely, the Temiskaming, Beaver, King Edward, and Colonial mines, where it was found to have a thickness of about 1,000 feet. At a fifth place, the North Cobalt property on the western outskirts of the town of North Cobalt, the diabase was penetrated to a depth of 700 feet without reaching the bottom of the sill.

These five points extend along a distance of over four miles, proving fairly conclusively the thickness of the sill.

In South Lorrain the thickness of the Nipissing diabase sill has not yet been determined.

Sill Probably Intruded from Southeast

Although the direction from which the Nipissing diabase sill was intruded may not be an important question, it may be put on record that the sill was in all probability intruded from the south-east toward the northwest. The evidence for this statement was obtained at the Beaver mine. Here, at the top of the Nipissing diabase sill, a great block of granite about 150 feet long was found included, caught up, in the sill. To the southeast a few hundred yards a batholith of Algoman granite, similar to the inclusion, occurs, and it is evident that, as the diabase sill forced its way northwestward through the granite mass, it caught up a block of this granite during its progress.

Keewatin "Iron Formation"

The term Keewatin "iron formation" is frequently used throughout the report. The rocks belonging to the formation consist of chert, finely bedded, together with slate and greywacké. These beds have been tilted up into vertical or nearly vertical attitude. The formation contains very little iron oxides, although iron pyrites is common, so that the name "iron formation" is, perhaps, a misnomer. But similar rocks occur elsewhere in the Province of Ontario and in the Lake Superior region interbedded with bands of iron ore. Hence the cherty beds and associated slate and greywacké are usually called "iron formation." It has frequently been met with in the mine workings which have penetrated below the Cobalt series into the underlying Keewatin.

The formation is of some importance in relation to the silver veins at Cobalt, as it has guided the course of certain veins; that is to say, some of the veins have followed the strike and dip of the "iron formation." This subject is referred to elsewhere.

Two of the most prominent bands of "iron formation" in Cobalt may be mentioned. One of them occurs in the deep bay of Sasaginaga lake. This bay extends eastwardly into the Trethewey property. The "iron formation" here consists of a bed of slate about 300 feet thick. On the south side of the bed there is a band of finely bedded siliceous material which passes into the slate. The formation was encountered in the workings from No. 6 shaft of the Trethewey below the Cobalt series. The other prominent bed of "iron formation" occurs in the depression under Clear lake; it extends eastwardly into the Townsite property. The bed consists mainly of chert and slate and appears to be wider than the bed at Sasiganaga lake.

There are several other beds of "iron formation" in this area. It may be added that it is difficult to distinguish the Keewatin "iron formation" from similar beds in the Timiskaming series. For instance, the vertical beds of chert or slate met with in the Genesee mine, below the Cobalt series, have been classed with the Keewatin "iron formation." It is reported, however, that "pebbles" have been found in these beds. If well defined "pebbles" do occur, it is more likely that the formation at the Genesee belongs to the Timiskaming, since the occurrence of true pebbles in the Keewatin iron formation is unknown at Cobalt.

Minerals Occurring in the Veins

The most important mineral in the veins is native silver. Other silver-bearing minerals are dyscrasite, argentite, and pyrargyrite. The ores of the metal cobalt are mainly smaltite and cobaltite. The gangue is chiefly calcite.

Miller gives the following list of minerals.[1]

- I.—Native Elements:
  - Native silver, native bismuth, graphite.
- II.—Arsenides:
  - Niccolite, or arsenide of nickel, $NiAs$; chloanthite, or diarsenide of nickel, $NiAs_2$; smaltite, or diarsenide of cobalt, $CoAs_2$.
- III.—Arsenates:
  - Erythrite, or cobalt bloom, $Co_3As_2O_8+8H_2O$; and annabergite, or nickel bloom, $Ni_3As_2O_8+8H_2O$; scorodite, $FeAsO_4+2H_2O$.
- IV.—Sulphides:
  - Argentite, or silver sulphide, Ag_2S; millerite, or nickel sulphide, NiS; argyropyrite? stromeyerite? $(Ag, Cu)_2S$; bornite, Cu_5FeS_4; chalcopyrite, $CuFeS_2$; sphalerite, ZnS; galena, PbS; pyrite, FeS_2.
- V.—Sulpharsenides:
  - Mispickel, or sulph-arsenide of iron, $FeAsS$; cobaltite, or sulph-arsenide of cobalt, $CoAsS$.
- VI.—Sulpharsenites:
  - Proustite, or light red silver ore, Ag_3AsS_3; xanthoconite? Ag_3AsS_4.
- VII.—Antimonides:
  - Dyscrasite, or silver antimonide, Ag_6Sb; breithauptite, $NiSb$.
- VIII.—Sulphantimonites:
  - Pyrargyrite, or dark red silver ore, $Ag_3\,SbS_3$; stephanite, $Ag_5\,SbS_4$; polybasite? $Ag_9\,SbS_6$; tetrahedrite, or sulph-antimonite of copper, $Cu_8Sb_2S_7$; freibergite? (silver-bearing tetrahedrite).
- IX.—Sulphobismuthites:
  - Matildite, $AgBiS_2$; emplectite, $CuBiS_2$.
- X.—Mercury:
  - Amalgam?
- XI.—Phosphate:
  - Apatite.
- XII.—Oxides:
  - Asbolite; heubachite?; heterogenite?; arsenolite; roselite?
- XIII.—Veinstones:
  - Calcite, dolomite, aragonite, quartz, barite, fluorite.

---

[1] Guide Book, Sudbury, Cobalt, South Lorrain, Kirkland Lake, Porcupine and Timagami, Ont. Dept. Mines, 1923, p. 98.

In addition to the minerals in the above list, H. V. Ellsworth has identified the following: löllingite ($FeAs_2$), rammelsbergite ($Ni As_2$), chalcocite (Cu_2S), symplesite ($Fe_3As_2O_8+8H_2O$).[1]

T. L. Walker has identified the mineral cosalite ($2PbS. Bi_2S_3$) from the Columbus mine at Cobalt.[2]

T. L. Walker and H. V. Ellsworth identified in 1914 the mineral temiskamite (arsenide of nickel) from the Moose Horn mine, Elk lake.[3]

Mr. Hugh Park, general manager of the Nipissing mine, gave to Willet G. Miller, Provincial Geologist, a speciment of the rare mineral sphærocobaltite, the proto-carbonate of cobalt ($CoCo_3$) from the Nipissing mine. The mineral has a delicate rose-red colour.

Mr. C. A. Knittel detected minute quantities of platinum and palladium in anode slimes resulting from the electrolytic refining of silver recovered by smelting ores from Cobalt.[4]

Epsomite ($MgSO_4+7\ H_2O$).—In some of the old workings of the mines at Cobalt the writer found here and there a coating of white material. This coating consists of a fine net-work of white, hair-like, fragile needles, which vary in length from fractions of an inch to as much as two inches or more. The width of of the needles may be from a fiftieth to one-hundedth part of an inch; possibly some of them may be as thin as cobwebs.

This net-like coating is sometimes half an inch thick and occurs on the floors, walls, and roofs of the workings, although mainly on the floors. As far as could be observed the material occurs where the workings are dry.

A sample of the mineral, which without doubt was deposited after mining had begun, was submitted to W. K. McNeill, Provincial Assayer. Mr. McNeill found the material to be epsomite, the hydrous sulphate of magnesium. The sample analyzed was obtained from the City of Cobalt mine on the third level, in a drift south of the "galena" fault.

Origin of Ores—Primary Character of Native Silver

It is now generally accepted that the ores have been deposited from mineral-bearing solutions which were given off by the Nipissing diabase. Miller was the first geologist to suggest this origin. The theory has stood the test of two decades, although numerous papers have been published espousing the secondary hypothesis.

Miller's views, and the views of certain other writers, regarding the origin of the ores are quoted below.[5]

> The material in these veins has, in all likelihood, been deposited from highly heated and impure waters which circulated through the cracks and fissures of the crust and were probably associated with—followed—the Nipissing diabase eruption.
>
> The waters are said to be associated or connected with the diabase eruption in the sense that they probably represented the end product of the eruption. In many volcanic regions hot springs are present long after the rocks have been solidified. In the Cobalt area the fissures

---

[1] Ont. Bur. Mines, Vol. XXV, 1916, pt. I, p. 200.

[2] University of Toronto Studies, Geological Series No. 12, 1921, by T. L. Walker.

[3] T. L. Walker, Am. Jour. Sci., 1914, Vol. 37, p. 120.

[4] Jour. Can. Inst. Chem., Vol. 6, 1922, Aug., pp. 179-180.

[5] The Cobalt-Nickel Arsenides and Silver Deposits of Timiskaming, by Willet G. Miller, Ont. Bur. Mines, Vol. XIX, pt. II, p. 8.

Guide Book No. 7, Int. Geol. Cong., 1913, issued by Ont. Bur. Mines, pp. 91-95.

and joints now occupied by the ores were probably produced by the gradual shrinkage in cooling of the diabase, the ores being deposited by the waters which represented the last stage of vulcanicity.

It is rather difficult to predicate the original source of the metals—silver, cobalt, nickel, arsenic and others—now found in these veins. They may have come up from a considerable depth with the waters or they may have been leached out of what are now the folded and disturbed greenstones and other rocks of the Keewatin. Analyses of various rocks of the area have not given a clue as to the origin of the ores. However, the widespread occurrence of cobalt veins in the diabase, or in close association with it, shown by discoveries during the last seven or eight years, throughout a region three thousand square miles or more in extent, appears to be pretty conclusive proof that the diabase and the ores come from one and the same magma.

After the intrusion of the Nipissing diabase sill, which, on the whole, dips at a low angle from the horizontal, and penetrates both the Cobalt series and the Keewatin, disturbance, probably due chiefly to the contraction of the sill on cooling, caused fissures and joint-like cracks to be formed. These openings were made in the rocks of the hanging-wall of the sill, in those of the foot-wall, and in the sill itself.

Ore-bearing waters working through or along the zone of weakness produced by the sill deposited their burden in the fissures and cracks. The minerals first to be deposited were essentially cobalt-nickel arsenides, and related compounds, and dolomite or pink spar. The fissures and cracks were ultimately filled with these minerals. Then there was a slight disturbance of the veins, reopening the ore-filled fissures and cracks, or fracturing the material deposited in them.

In the interval, between the filling of the fissures and cracks with cobalt-nickel ores and the fracturing of the veins thus formed by a secondary disturbance, the character of the material carried by the circulating waters had changed. Silver was then the characteristic metal in solution and it was deposited, along with calcite, in the cracks and openings in the fractured veins. There may have been some silver deposited in the earlier period of vein filling and doubtless cobalt-nickel minerals were deposited after the secondary disturbance, but the latter minerals belong characteristically to the first generation and the silver minerals to the second.

Certain writers on the Cobalt ores have expressed the opinion that the silver represents "secondary enrichment," meaning that it has come from the decomposition of compounds of the metal in the veins that were deposited at approximately the same time as the cobalt-nickel minerals. The present writer believes that at least by far the greater part of the native silver is of primary origin. The recent interesting experiments of Messrs. Chase Palmer and Edson S. Bastin,[1] on the precipitation of silver from solutions by cobalt-nickel minerals, appear to confirm the opinion that the native silver is a primary deposit, and did not come from the decomposition of silver compounds in the veins. The work of these gentlemen shows that where silver solutions come in contact with cobalt-nickel minerals the silver is deposited rapidly and essentially as native silver. Since there is much calcite in the veins with the native silver, it would appear that the metal was carried in solution as a carbonate, or double carbonate. Under ordinary conditions of temperature and pressure, silver carbonate is slightly soluble in water. For example, sufficient of the carbonate can be dissolved in an ordinary beaker of water to make a distinct precipitate of metallic silver when cobalt-nickel minerals are placed in the beaker.

It has been proved, by the experience gained in mining at Cobalt, that the presence of rich silver ore is dependent on proximity to the diabase sill. Over much of the productive area, not only the upper wall of the sill but the sill itself and more or less of its foot-wall have been removed by erosive agencies. Owing to little of the upper or hanging wall remaining in the productive area, most of the ore has come from the foot-wall of the sill, or from what was the foot-wall before erosion took place. In these veins, in the foot-wall of the sill, it is the exception to find rich silver ore extending more than two or three hundred feet below the surface. Most veins are productive to a lesser depth. After rich silver ore disappears, with increase in depth, cobalt-nickel ore frequently continues downward in the veins. This seems to be due chiefly to the strong precipitating effects that the cobalt-nickel minerals had on the silver in the waters that worked downward beneath or along the sill. The silver was deposited before it reached a great depth. In certain cases, where veins with cobalt-nickel minerals contain no rich silver ore, or in which the silver extends to a comparatively shallow depth, the absence of the precious metal is to be accounted for by the fact that such veins, or parts of veins, escaped fracturing during the secondary disturbance, thus not affording openings for deposition from the silver-bearing solutions.

Frequently, below the rich silver-bearing parts of veins, well crystallized argentite and hair silver are found in vugs. These minerals may represent secondary deposition of a little of the silver that has been dissolved from the upper part of the veins and carried downward.

Characteristically, the native silver of the area is impure, chiefly from the presence of antimony and mercury. Samples of well crystallized silver and certain veinlets of the mineral that have been examined are free from these impurities. Such silver is probably of secondary origin.

When native silver is precipitated by its solutions coming in contact with cobalt-nickel minerals, compounds of nickel and other metals go into solution. Hence, it is not surprising to find in the Cobalt veins minerals or compounds of the baser metals that appear to have been deposited during the later period of vein filling.

---

[1] Econ. Geol., March, 1913.

Regarding the primary origin of the silver Edson S. Bastin concludes as follows:[1]

> Field and office studies of the ores of the Frontier mine show that nearly all of the native silver is a late primary mineral. Native silver is the principal valuable mineral of the ores. Most of it was deposited late in the primary mineralization. As the nickel and cobalt arsenides prevailingly show their own characteristic crystal faces against the silver the latter can not have replaced them. What appear at first sight to be replacement veins of silver and calcite traversing the arsenides are shown to be fillings of minute rifts developed during crystallization.

J. Mackintosh Bell has found that some of the silver in the Keeley mine is secondary. Regarding this secondary silver Bell concludes:[2]

> What little microscopic work that has been done on the Keeley ores serve to corroborate the evidence, derived from analyses and gained more particularly from the careful accumulation of geological data, that a substantial part of the silver in certain of the rich shoots of the Keeley is secondary and derived from the impoverished highly oxidized upper portions of the veins. In making this statement the writer does not attempt to combat the now generally accepted theory as to the hypogene origin of the primary ore in veins of the cobalt type, to which those of the Keeley mine clearly belong. Much of the Keeley ore is probably purely primary and has gained no enrichment from descending solutions, but in other parts of the mine, where, indeed, the richest ore has been found, there would seem no reason to doubt the existence of widespread changes, which have materially altered and enhanced the value of the primary mineralization.

The views, regarding the origin of the ores, of an eminent geologist of his day, the late S. F. Emmons, are of interest in an historical way. Emmons, in 1910, considered that the silver was of secondary origin, and that the veins as they are found to-day are but the roots of veins that once could have been measured in thousands, rather than in hundreds of feet in depth. It may be added that his ideas have not been generally accepted.[3]

> Doubtless most of you are more or less familiar with the general geological relations of the Cobalt district as given by the Canadian geologists. My own examination of the district has been too brief and cursory to justify any criticism of their determinations, which I therefore accept as far as the areal geology is concerned. The ore deposits are, however, of so remarkable a nature and so utterly different from anything seen within the boundaries of the United States that I have thought it might be interesting to you to hear what particularly impressed one who has had considerable experience in the study of the latter.
>
> I could find no evidence that the silver had been introduced from below by a later accession of metal-bearing solutions, as seems to have been implied, if not explicitly stated, by those who have written on the subject, and I am inclined to believe that the second period of fracturing has served simply to furnish channels for descending silver solutions. I further believe that the reason that in the early veins the very rich ores did not extend far into the underlying Keewatin is to be found less in the fact that the Keewatin is unfavourable to the formation of fissures, than because the downward limit of secondary enrichment had been reached about at that depth. The change from rich to poor ore is certainly a remarkably abrupt one. In the No. 3 Kerr Lake mine, it occurs within 20 ft. or so, and in the No. 7 vein at the shaft it has been said that within two feet the ore dropped from 2,000 to 20 oz. The depth at which this change takes place is extremely variable. There are cases in which it has occurred within a few feet of the surface, and as already stated in the No. 3 Kerr Lake vein it is at a depth of over 300 ft. That denser, more plastic rocks may have an unfavourable influence, since in them there is less likelihood of cracks that are sufficiently open to admit the descending solutions, is quite probable, but there does not seem to be any general association of this condition with the bottoming of the bonanzas. I have in mind a single case. In the north-south portion of the No. 7 Kerr Lake vein, the bonanza seemed to stop at a band of dense black indurated slate which dips northward with the other sedimentary formations, but is above the so-called Huronian (Cobalt series) conglomerate, already spoken of as resembling a tillite. In the northwestern part of the claim, however, where this slate band has not been distinctly recognized, the bonanza has already gone down 50 ft. below the horizon the slate should occupy, and has reached a depth of 190 ft., whereas at the shaft it stopped within 100 ft. of the surface. At other points observed there seemed to be no change of rock associated with the bottoming of the bonanza zone. The microscopic study of polished specimens of the same vein in and below the bonanza discloses, as the main difference, the absence in the latter of the minute cracks traversing the vein material that characterize the former, and that evidently have served as channels for the introduction of the silver.

---

[1] Primary Native Silver Ores of South Lorrain near Cobalt, Ontario, by Edson S. Bastin, Geol. Soc. Am., Ann. Meeting, 1923.

[2] Deep-seated Oxidation and Secondary Enrichment at the Keeley Silver Mine, by J. Mackintosh Bell, Econ. Geol., Vol. 18, Oct.-Nov., 1923, pp. 684-694.

[3] Read before the Geol. Soc., Washington, January 26, 1910.

Mr. Van Hise has stated, as a general truth, that openings in the zone of fracture of the rocky crust gradually decrease in size as depth increases, and doubtless many of you have had occasion to observe, as I have, cases where the opening of a given fissure vein decreases very perceptibly as distance from the original surface increases, and that a fissure-opening that may have a width of many feet in its upper part, if followed to sufficient depth, is found to end in a series of very small cracks whose width is to be measured in inches rather than in feet. It would seem, therefore, that the natural conclusion to be drawn from the extreme narrowness of the fissures in the Cobalt region is that they were originally formed under the pressure of a great weight of superincumbent rock or at great depth below the then existing surface; hence that the greater part of these original fissures has been eroded away, and what we see to-day are merely the roots of veins that once could have been measured in thousands rather than hundreds of feet. The question then is, what evidence is to be found in the geological history of the region that would justify this conclusion? Let us search and see.

The geology of the region to the north of the Great Lakes and west of Hudson Bay has not yet been worked out in detail, but its general character is assumed to be a great plateau of low relief, composed largely of pre-Cambrian rocks in which are patches of early Paleozoic beds that have escaped erosion, presumably through being enclosed in synclinal troughs, in like manner as have the Triassic beds which are found to be infolded with the crystalline schists in the Piedmont region west of Washington. The veins, as has been seen, cut through both series of pre-Cambrian rocks as well as the igneous rocks that have been intruded into them, but so far as known did not penetrate the Paleozoic sediments, and are hence assumed to be of pre-Cambrian age. From the manner in which the exposures of the two unconformable members of the latter series are distributed, it is evident that there must have been a considerable period of erosion before the Paleozoic beds were deposited over them, though there seem to be no criteria for estimating the length of that period. Since these beds were deposited, however, and the region has been again raised above the sea, it has been exposed to sub-aerial degradation continuously up to Glacial times, which in itself is a much longer period than the entire existence of the ores of Mesozoic or Tertiary age, which constitute by far the greater part of the ore deposits of the Rocky Mountain region. The evidence afforded by the peculiar character of the phenomena of secondary enrichment at Cobalt furnishes, to my mind, a still more convincing argument in favour of the assumption that the veins, both primary and secondary, are extremely old and have been exposed to degradation for an immensely long period, for secondary enrichment and degradation are processes that go on *pari passu,* and in a given region are necessarily coordinated. It seems fair to presume, then, that the erosion and wearing away by the continental glacier was only the emphasizing of a similar process that had been going on, though at a slower rate, for much longer periods of time. Secondary enrichment of ore deposits proceeds in a sort of arithmetical progress. As the vein with its enclosing rocks commences to wear away, certain of its metallic contents, rendered soluble through oxidation, are leached down and redeposited at a lower level, which we call the zone of sulphide enrichment because the ore in that region is abnormally enriched. But this enriched zone is gradually brought nearer the surface by continued wearing away of the latter; hence increasingly richer material is carried down, and the zone of secondary enrichment is constantly increasing in richness; but the primary ore beneath this zone, which is not reached by the enriching solutions, remains constant and unchanged in the condition in which it was originally deposited. Thus there seems no limit to the amount of enrichment that may take place, provided sufficient vertical extent of original vein is provided, and enough time allowed for wearing it down to its roots.

C. R. Van Hise,[1] in 1907, believed that most of the silver was secondary and was deposited through the influence of descending surface waters bearing oxygen. His views are given more fully in Chapter V.

Secondary Silver

Regarding the secondary origin of silver in the veins at Cobalt, there is evidence in vein No. 64, Nipissing mine, that silver has been deposited at two different periods in the history of the vein.

During the first period in the history of this vein, No. 64, the primary silver minerals, native silver and certain other silver minerals and cobalt and nickel arsenides, were deposited. Then the vein, a very high-grade one rich in native silver, was slightly fractured and cracks a quarter or half an inch wide were formed in the vein at right angles to the wall-rock. Along the walls of these cracks, which are partly open and vuggy, were deposited crystals of calcite; and on top of these crystals of calcite there were deposited crystals of argentite, ruby silver, and stephanite. These crystals of argentite, ruby silver, and stephanite belong to the second period in the history of the vein. It is probable that this silver of the second period of deposition is secondary, and was leached out of the vein higher up and deposited in its present position. It may be added that the writer observed very little of this secondary ore.

---

[1] The Ore Deposits of the Cobalt District, Ont., by C. R. Van Hise, Jour. Can. Min. Inst., 1907, Vol. X, pp. 45-61.

Some of the silver at the Keeley mine in South Lorrain is also secondary. This is discussed in Chapter III.

Surface Geology

Keewatin Lava Flows.—The work of this report was designed essentially to obtain and publish a record of the geology of the underground workings of Cobalt and South Lorrain. Hence practically all of the time was spent in the mines. A few weeks were devoted, however, to surface work, particularly in the Keewatin rocks between Cobalt and Sasaginaga lakes.

The Keewatin rocks in this area consist of several beds of "iron formation" interbedded with basalt. The "iron formation" is made up of banded chert, slate, and greywacké. The whole series, basalts and "iron formation," rests in almost vertical position, with a steep southward dip, and a strike of a few degrees north of west. The total thickness is unknown, but it exceeds one mile.

The only explanation which the writer has to offer as to the origin of this series is that the basalts are lava flows, and that the "iron formation" beds are of sedimentary origin, interbedded with the lava flows. After the beds were formed the whole series was tilted up into vertical position.

The occurrence of amygdules in rare cases, and the general fine or medium grained character of the basalts suggest their volcanic nature. It must be admitted, however, that the evidence for believing that the basalts constitute a series of lava flows is not as clear and indisputable as is the evidence regarding the wonderful series of flows in Lightning River and Cook townships south and southwest of Lake Abitibi.[1]

East of the north end of Sasaginaga lake there is a considerable area of fine-grained, grey felsite. It is not known whether this rock is a lava flow or an intrusion. Nor has its age relation to the beds of "iron formation" and basalts been definitely determined. The only clue of the age relationship was obtained in the Buffalo mine where a small dike of felsite cuts the "iron formation."

If a new surface map of Cobalt is ever published these beds of basalt and "iron formation," together with the felsite mass east of the north end of Sasaginaga lake, should be mapped in detail.

A little surface work was also done northwest of the town of North Cobalt. In a number of places there is evidence that a fault follows the valley which runs northwestward from the town of North Cobalt. In some pits, which were shown to us by Mr. Bennett, the fault breccia of the fault was observed, consisting of crushed rock cemented together by brown-weathering carbonate, probably dolomite or some closely related mineral. This fault probably extends southeastwardly along the drift-covered valley which lies immediately west of the Green-Meehan. The fault was met with in the long westward crosscut of the Ruby mine which is just west of the Green-Meehan.

In South Lorrain some days were spent on the surface, working out the form and structure of the Nipissing diabase. It was found to occur in the form of a sill of unknown thickness. The sill forms a great elongated dome. A description of this dome is given in that part of the report dealing with South Lorrain.

---

[1] Abitibi-Night Hawk Gold Area, by C. W. Knight, A. G. Burrows, P. E. Hopkins, and A. L. Parsons, Ont. Bur. Mines, Vol. XXVIII, pt. II, pp. 9-17.

Black River Area, by D. G. H. Wright, Ont. Dept. Mines, Vol. XXX, pt. VI, pp. 33-42.

Correspondence Regarding Re-Survey of the Cobalt Silver Area

The following letter was written on December 20, 1919, to Dr. Willet G. Miller by the Timiskaming Mine Managers' Association, requesting the Ontario Government to undertake further geological survey work in the Cobalt silver area. As the letter resulted in the publication of this report it is printed here for purposes of record.

TEMISKAMING MINE MANAGERS' ASSOCIATION

Cobalt, Ontario, December 20, 1919.

W. G. MILLER, ESQ.,
Bureau of Mines,
Parliament Buildings, Toronto.

Re Geological Survey of Cobalt Silver District

DEAR SIR,—

At a recent meeting of this Association the matter was discussed regarding a further geological survey being made of the Cobalt district.

Being so instructed, we beg to communicate with your Department, placing this matter before you for your kind consideration.

You will appreciate that underground development has continued to verify the early conclusions of your Department.

With such further data as these developments have made available at various contact points, and by referring to stoping production records, it is very probable that the location of most important ore deposits will result from a thorough study of the geological conditions as are at present exposed in the Cobalt district. This is an essential work which would doubtless result in materially increased revenues to the Province, and the members of this Association will be pleased to be of any possible assistance to your Department in procuring the desired information.

This suggestion was one of several placed before Premier Drury and his colleagues during their recent visit to Northern Ontario, and we hope, after your consideration, that you may be able to arrange for the completion of this further geological survey, which will result in material and mutual benefit to the Province and the Cobalt mining industry.

Thanking you in anticipation, we are,

Yours truly,

TEMISKAMING MINE MANAGERS' ASSOCIATION,

(Sgd.) H. A. Kee, *President.*

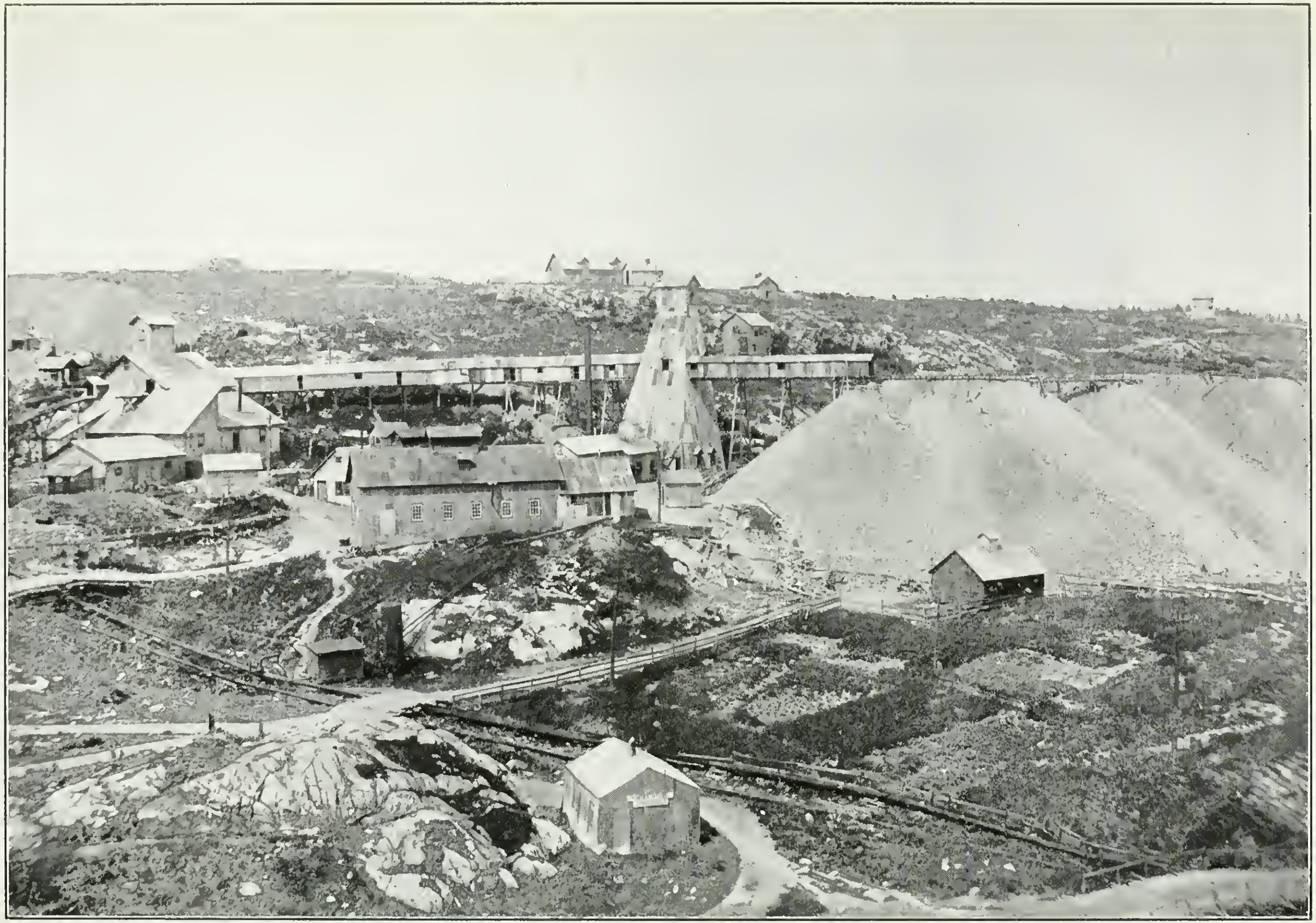


Fig. 11—Meyer shaft, No. 73, Nipissing mine. All of the ore from the Nipissing north of Cobalt lake is hoisted from this shaft.

CHAPTER II

GEOLOGY OF THE MINE WORKINGS

In following pages there will be found a description of the mine workings of nearly every property in the Cobalt area proper. An account of the mines in South Lorrain is given elsewhere in this report.

The order in which the properties are arranged is based on the number of ounces of silver which each company has produced. Thus, at the head of the list will be found the Nipissing mine, the output of which to the end of the year 1922 amounted to 65,700,579 ounces.

In describing the various levels of each mine it has been found convenient to begin with the lowest level and then deal with higher and higher levels. This order of description has been adopted because, as a general rule, the examination and mapping were begun on the lowest level of each mine.

The reader will be able more readily to follow the descriptions if he will use the plans in the pocket at the back of the report.

Mine managers at Cobalt who are familiar with every stope, drift, crosscut, and winze in their respective properties may find the descriptions lacking in many desirable details, particularly in reference to veins mined out previous to our examination. Little or nothing could be learned from an investigation of an empty stope, the ore-bodies of which have long since been worked out. It is hoped, however, that the general descriptions given will be of some value to mining men who have had neither the opportunity nor the time to examine all of the mines at Cobalt for themselves. Moreover, it may perhaps be added that later generations of engineers and geologists will read, at least with curiosity, if not with profit, the descriptions of what to them will be ancient mine workings!

In addition to the properties described in following pages there are many other prospects or mines which were not accessible, or which the writer did not have an opportunity to examine. They are consequently not described. Among these mines, descriptions of which are not given, are the following: Nova Scotia, Silver Cliff, King Edward, the mine workings under Peterson lake, the property known as "A.53" on Giroux lake, Shamrock, Badger, Cochrane, Waldman, Silver Bar, and others. Then, too, there are scores of claims on which more or less work has been done, such as the sinking of shallow shafts, open pits, trenching, and so forth, but which are not mentioned.

Those seeking information regarding these properties will find the reports of the inspectors of mines, in the annual volumes of the Ontario Department of Mines, of valuable assistance. It would have been possible to republish these descriptions in the present report; this, however, would have made the report of unwieldy bulk.

By making use of the general index to the annual volumes of the Ontario Department of Mines and of the index accompanying each volume, the reader will obtain references to information regarding many properties not mentioned in this report.

The aim of the writer has been to furnish descriptions and plans of all the principal producing mines. This, in large part, has been accomplished.

NIPISSING

The Nipissing Mines Company, Limited, has an authorized and issued capital of $6,000,000, consisting of 1,200,000 shares of the par value of $5. In respect of the total silver output, the dividends paid, the number of veins, and the number of productive acres owned, the company is the most important in the entire silver field.

To the end of the year 1922, the property had produced 65,700,579 ounces of silver, and had paid in dividends $24,720,000. The company owns 846 acres in the heart of the area, of which 422 acres are underlain by rocks of the Cobalt series, 238 acres by Nipissing diabase, and 186 acres by rocks of the Keewatin series.[1]

To the end of the year 1922, there were 28.2 miles of underground work, including drifts, crosscuts, raises, winzes, and shafts.

The writer has perused the eighteen annual reports of the Nipissing Mines Company, Limited. They are familiar to the engineers at Cobalt, but they may be commended to mining engineers elsewhere. They are models of accuracy, clearness, conciseness, and, above all, of integrity. The late Mr. R. B. Watson, the general manager, who was the dean among the mining fraternity at Cobalt, has signed all but the first three of the reports. They have been used freely in preparing the present report, and acknowledgment is herewith made.

Costs

The cost of producing silver in the year 1922 at the Nipissing is detailed in the following table, based on a production of 3,423,114.80 ounces and 82,025 tons of ore. The figures are given in the eighteenth annual report of the company.

Expenditure	Amount	Per ton ore	Per oz. silver
	$	$	Cents
Diamond drilling	31,544,22	.385	.921
Exploration	125,660.15	1.532	3.671
Development	103,600.96	1.263	3.027
Stoping	118,469.22	1.444	3.461
Hauling dumps	7,077.76	.086	.207
Assaying and engineering	12,995.28	.158	.380
Loading residue	547.39	.007	.016
Tailings disposal	640.33	.008	.019
Assorting and teaming Cobalt ore	13.09	.000	.000
Administration and office	50,948.71	.621	1.488
Camp maintenance	4,176.37	.051	.122
Insurance and taxes	126,264.74	1.539	3.689
General and legal	20,053.93	.245	.586
High-grade mill	136,354.96	1.662	3.983
Low-grade mill	343,567.91	4.189	10.037
Depreciation	32,571.24	.397	.951
Marketing product	21,882.71	.267	.639
Corporation, New York office, and travelling	19,441.54	.237	.568
	$1,154,529.85	14.075	33.727
Less rents, exchange, and miscellaneous income	27,008.93	.329	.789
Total cost of production	$1,127,520.92	13.746	32.938

---

[1] Seventh Annual Report, Nipissing Mines Company, for year 1911, p. 10.

Development in Year 1922

An account of the development work which took place in the year 1922 has been given by Mr. R. B. Watson, the general manager, in the eighteenth annual report of the company, and is quoted in following paragraphs:—

> All mining operations were considerably increased during the year. Work was carried on at six shafts, all widely separated. The total underground advance was the largest in several years; it was 63 per cent. more than in 1921.
>
> The number of faces worked was 170, exclusive of stopes, of which there were 20.
>
> Several new veins of moderate importance were discovered. The greatest increases of known ore, however, were obtained in the stopes of the older veins, particularly 64 and 490, and in the satisfactory development of vein 251 (south of Cobalt lake), found a year ago.
>
> *Shaft 19.*—A large tonnage of mill-rock was mined from No. 6 open cut. The stope is increasing in length, and there is still a considerable area to be broken.
>
> Vein 130 will also be mined through this shaft. It is smaller than No. 6, but the vein contains more high-grade ore.
>
> Stoping operations were confined to the summer months, as the broken rock freezes during the winter.
>
> *Shaft 26 (Vein No. 26 north of Peterson lake).*—A large production was obtained from this shaft during the early period of the property, but it has not been worked in recent years. The vein was extremely high-grade and was mined to a depth of 200 feet. It was one of the few veins of the district that produced any considerable amount of silver from the Keewatin formation.
>
> The shaft was pumped out and repaired during the latter part of the year, and a large amount of exploration and development will be done. Particular attention will be given to an area near the lower contact of the diabase sill and the Keewatin.
>
> Shaft 26 was worked before the company had a mill for the treatment of low-grade material; only high-grade ore was sought. It is probable that the old stopes contain unbroken low-grade ore which can now be recovered and treated at a profit.
>
> *Shaft 63.*—All mining work was increased during the year. A few small veins were found, but the most important result of the year's work was the favourable development of vein 251.
>
> A new level was started just above the Keewatin contact, 55 feet below the discovery level. A drift at the lower level shows a continuous ore-shoot 265 feet in length. The vein is 2 inches wide and has an average assay of 2,900 ounces. The present estimated ore reserves in vein 251 will probably be materially increased by vertical development, now under way.
>
> After producing a large tonnage during the year, the ore reserves at shaft 63 show practically no decrease, and are about one-half of the total reserves at all shafts.
>
> *Shaft 64.*—Stoping was actively carried on throughout the year. Notwithstanding a large production, the ore reserves show only a small decrease.
>
> There is still an area to be mined which contains high-grade ore and which will also produce a large amount of mill-rock.
>
> *Shaft 73.*—As in former years, this shaft produced most of the tonnage treated. After sending 42,000 tons to the mill, the reserves show an increase in tons and only a slight decrease in silver ounces.
>
> Several new veins of fair importance were found. Faulted portions of a number of others were favourably developed and will produce a considerable tonnage in the future.
>
> An important development was made on vein 490. While stoping a low-grade section of the vein, a high-grade shoot was encountered which more than compensated for withdrawals made during the year. The vein is 6 to 8 inches in width and assays several thousand ounces over a length of 60 feet.
>
> Vein 490 has been a consistently large producer for several years and the present reserves show an increase over the previous year.
>
> *Shaft 80.*—No work was done during the year.
>
> *Shaft 128.*—No favourable developments were encountered, and the shaft was closed late in the year, the equipment being transferred to shaft 26 (vein No. 26).

Veins

In the description of the Nipissing veins in following pages only the more important ones are dealt with. As the veins on the property are numbered in the hundreds it is clearly impossible, in a report of this nature, to deal with all of them.

Ore Reserves

At the end of the year 1922, the ore reserves, according to the annual report of the company for the year 1922, consisted of 1,205 tons of high-grade ore averaging 1,321 ounces of silver per ton, or 1,592,000 ounces; and of 57,338 tons of low-grade ore averaging 18 ounces of silver per ton, or 1,023,469 ounces. This makes a total of 2,615,469 ounces of silver.

In 1911, the area north of Cobalt lake, or east of the Coniagas, Trethewey, and Hudson Bay mines, became the most important producer and yielded three-quarters of the year's output. This area continued to produce a large proportion of the ore until 1921, when more than half the underground development took place on the southeast side of the lake, and the ore reserves were about equally divided between the two sides. In 1922, the ore reserves at shaft No. 63 were about one-half of the total reserves at all shafts.

Nipissing Mine Workings

In describing the Nipissing mine workings the ground may be divided roughly into two parts, that north of Cobalt lake, and that southeast of it. The ore is hoisted mainly in two shafts, namely, No. 73, north of the lake, and No. 63, southeast of the lake, although four other shafts of much less importance were in use in 1922, and there are a number of other shafts not now used.

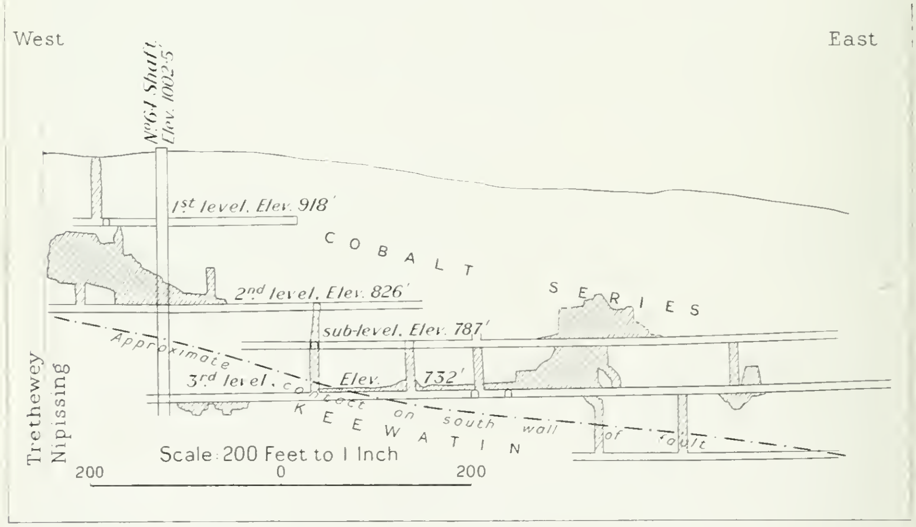


Fig. 12—Stope section on vein No. 64, Nipissing.

Mine Workings North of Cobalt Lake

The level plans of this part of the property are shown on sheet No. 31a-11.

The rocks consist of the Cobalt and Keewatin series. In the southeast corner of this part of the Nipissing, the Cobalt series attains a thickness of about 600 feet, its greatest known thickness in the Cobalt area proper.

The veins in this area belong to the same vein-system as do the veins on the Coniagas, Trethewey, and Hudson Bay. Vein No. 490 on the Nipissing, however, does not appear to have any direct connection with the Coniagas, Trethewey, or Hudson Bay veins.

There are four great systems of veins in this ground, namely: (1) vein-system No. 64, which is the eastward extension of veins on the Hudson Bay; (2) the Meyer vein-system, which is the eastward extension of the "main" vein on the Trethewey; (3) vein-system consisting of veins No. 80 and No. 100, which is the eastward extension of veins on the Coniagas; vein No. 80 has been called the

"Fourth of July"; (4) vein No. 490, which is at the east side of the area and strikes about north and south. Other veins of lesser importance occur.

Of these four vein-systems the Meyer, with its various branches, is the most important and intricate. The system extends across the entire property, and vein No. 98, the main branch of the Meyer vein, has been followed into the Chambers-Ferland a couple of hundred feet.

As the ore from many of these veins has been hoisted from shaft No. 73, it was not found possible to keep a record of the number of ounces of silver which each vein produced. Mr. Hugh Park, the manager, has, however, estimated that the production of the Meyer vein will amount to approximately 13,000,000 ounces of silver. This does not include any of the branch veins from the Meyer vein. The main branch, No. 98, of Meyer vein will produce approximately 4,000,000 ounces, according to Mr. Park.

The most northerly vein in this area is No. 64. It strikes eastward and dips to the south at angles of 70° to 90°, the flatter dip occurring on the lower workings. The vein occurs in a fault which is apparently a normal one, the south side having been faulted down 10 to about 25 feet, but it was not found possible to determine the exact amount of displacement. On the Hudson Bay property the displacement is not as much as it is on the Nipissing. There has been horizontal movement as indicated by the more or less horizontal scratches on the walls of the fault. The fault breccia varies in width from a few inches to as much as 8 or 9 feet in places, and the gouge is as wide as an inch or two. The vein is one of the largest and strongest in the Cobalt area, and it has been prospected to a depth of 1,075 feet on the dip of the vein. Several valuable ore-shoots have been opened up in the Cobalt series, but the ore-shoots did not extend into the underlying Keewatin. The ore-shoots in the Cobalt series had a width of two or three inches to as much as 42 inches. As the vein in the Keewatin was strong and carried low values throughout, it was considered advisable to explore it at depth, and the main shaft, No. 64, was therefore sunk to the 902-ft. level (Fig. 4). On crosscuts at 440 and 650 feet, the vein was soft and decomposed and showed little change from the condition on the third level. At the 902-ft. level, a crosscut 272 feet long was necessary in order to reach the vein, which was then drifted on for 454 feet. From this level an inclined winze was sunk, and 53 feet of drifting done on the lowest level. All this work at depth failed to develop any pay ore; the vein, while narrower, is still strong, but only assays from 5 to 20 ounces of silver per ton. At the time of the writer's examination in 1921 these deep workings were inaccessible; the description given is taken almost word for word from the annual reports of the company.[1]

For several years little work was done on vein No. 64 in the Cobalt series and the ore reserves remained practically unimpaired. In 1921, stoping and development were increased, due to the completion of haulage facilities to the main hoisting shaft, No. 73. Substantial increases of ore reserves, both high-grade and mill-rock, resulted from this work. The average assay of the high-grade ore is about 1,000 ounces, but parts of the vein will assay much higher over widths of one to two feet. The vein is in the hanging-wall of the fault, and it generally rests on top of the gouge. In places it leaves the fault and runs parallel with it at a distance of two or three feet. In addition to the vein which is in the fault, there are veins which leave the fault and rise vertically upward for 40 or 50 feet (Fig. 14).

No ore-bodies have yet been found north of fault vein No. 64 on the Nipissing property.

---

[1] Annual Reports of the Nipissing Mines Company, Limited, for the years 1909, 1913, and 1914.

The Meyer vein-system is one of the most important in the area, and, at the same time, one of the most interesting and intricate. In 1913 it produced the major part of the year's production. The Meyer vein is the eastward extension of what is known as the "main" vein on the Trethewey. The stope-section (Fig. 5) of that part of the vein on the Nipissing shows a length of 1,100 feet, and of that part of the vein on the Trethewey of about 500 feet, a total of 1,500 feet. Branching from the east side of Meyer vein there are about a dozen branch veins, the most important of which is No. 98, which extends eastward across the Nipissing and runs into the Chambers-Ferland for one or two hundred feet, where it breaks into two or three branches which practically pinch out.

Meyer vein is an excellent example of how ore-shoots at Cobalt follow down along the contact between the Keewatin and the Cobalt series, the ore being almost entirely in the Cobalt series. The ore-shoot rises about an average height of 110 feet above the Keewatin (Fig. 5). The Meyer vein on the surface is a barren calcite vein, three-quarters of an inch or less wide, except where the high-grade shoot is exposed at the surface at the west end, owing to erosion. The general manager of the company, Mr. R. B. Watson, pointed out to the writer how the Meyer ore-shoot follows the Keewatin contact in the manner described; the stope-section referring to the Nipissing (Fig. 5) was kindly supplied by Mr. Watson, while the stope-section on the Trethewey was supplied by F. D. Reid of the Coniagas mine.

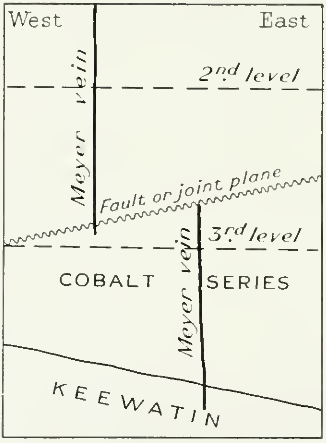


Fig. 13—Sketch showing relation between Meyer vein and fault, or joint, Nipissing mine.

The east and northeast part of Meyer vein-system occurs above a slight depression or trough in the Keewatin on the third and fourth levels; how much of the depression is due to folding the writer is not prepared to say, but some folding has taken place and may be seen in the Cobalt series on the third level near the Keewatin.

The Meyer vein strikes a few degrees north of east and continues with this strike for about 400 feet when it gradually turns northeastward and finally northward.

On the third level the Meyer vein has been faulted, apparently, a distance of 40 or 50 feet, the part of the vein above the fault, or joint, having moved 40 or 50 feet to the west. This is dealt with further in describing the third level (Fig. 13).

Vein-system No. 80 and No. 100 consists of two veins known by those numbers; No. 80 has been called the "Fourth of July" vein. They have been important producers and are the eastern extensions of veins on the Coniagas. Between the first and second levels the management met with a fault which made the development on the second level for a while quite uncertain. The fault problem was satisfactorily solved by the management, and the veins were finally picked up below the fault.

Vein No. 490 is one of the best producers owned by the company. It is at the east side of the property, 50 to 100 feet from the Chambers-Ferland boundary line. The vein strikes north and south, but at the north end it turns eastward and enters the Chambers-Ferland, and at the south end it turns southeastward and enters the Chambers-Ferland again. Most of the ore occurred on the Nipissing. In 1919, the vein had the largest ore reserves of any vein on the entire property. On the fourth and upper levels, the vein was barren. When the vein was first being explored, a winze was sunk from the fourth level on the vein to the Keewatin, but the results were not very favourable. It was found later that the winze went down at a poor spot with good ore on both sides. When drifting started on the fifth level, 431 feet below the collar of No. 73 shaft, results showed a great improvement; an ore-shoot 690 feet long was opened up, assaying 800 to 1,000 ounces of silver per ton. The vein averages five to six inches in width. On the sixth level, the ore-shoot has a length of 660 feet. In 1918, the average width of the stopes was ten feet; in that year the vein contained one-third of the total ore reserves.[1]

The ore-shoots on vein No. 490 are like those in the Meyer vein, that is to say, they occur in the Cobalt series near the Keewatin contact. The ore-shoots of vein No. 490 do not rise more than about 150 feet above the Keewatin. Thus the vein is barren from the fourth level to the surface.

Workings on Vein No. 64

A description of the geological details of the mine workings north of Cobalt lake may now be given, commencing with vein No. 64. The lowest accessible level of vein No. 64 in 1921, when the examination was made, was the fourth level, which is reached from No. 73 shaft. All the ore is now hoisted from this shaft. A description of the workings below the fourth level has already been given.

Fourth Level.—(Elevation above sea level 654 feet at the station of No. 73 shaft.) The vein, No. 64, had up to the year 1921 been drifted on for about 500 feet. Part of the back of the drift had been timbered, apparently on account of the fact that the rock falls readily, causing the drift to be dangerous were it not for the timbering. Where the fault, No. 64, could be examined it was seen to consist of crushed rock from a foot to four feet wide, together with the usual gouge fractions of an inch wide. The drift was made in a fortunate position, because it shows that the fault is a normal one and that the rocks on the south side have been displaced at least eight feet. This may be seen in a short crosscut running south of the drift. The vein, which is one to fifteen inches wide, consists largely of pink calcite, together with lesser quantities of smaltite. In one place the smaltite appears to be younger than the pink calcite, because the smaltite occurs in irregular stringers cutting the calcite.

Third Level.—(Elevation above sea level 732 feet at No. 64 shaft.) The west part of the level had two or three feet of water in it during the time of examination in August, 1921. The raise east of the shaft, however, between the third and second levels was accessible from the second level, and in it we were able to find that the contact between the Keewatin and the conglomerate of the Cobalt series was about 14 or 15 feet above the third level on the south side of the fault. The contact on the north side is, of course, higher up the raise, but how far we could not determine. It is certainly below the sub-level, next to be described.

---

[1] Annual Reports of the Nipissing Mines Company, Limited, for the years 1916, 1917, 1918, 1919.

The winze from this level down to the fourth level was also accessible; the Cobalt series occurs for eight feet below the third level, and the remaining part of the winze down to the fourth level is greyish-white felsite.

Sub-level.—(Elevation above sea level 787 feet at No. 64 shaft.) The workings on this level consist of a drift, 650 feet long, following the vein. Towards the east end, the vein has been stoped from the third level up to and a little above the sub-level.

The sub-level is reached by a ladderway on the second level; this ladderway is about 160 feet east of shaft No. 64.

The vein on the sub-level is a wide one, in places two feet. It consists largely of pink calcite. At one place it shows a width of ten inches of smaltite. The vein occurs on the south side of the fault and closely follows it, except here and there where it may be a foot or two south of the fault.

In the stope, there had formed in the vein, in places, cracks at right angles to the walls of the vein; these cracks contained calcite crystals in vugs, and growing on top of the calcite crystals were crystals of argentite, stephanite, and ruby silver. The argentite, stephanite, and ruby silver are thus secondary, and clearly younger than the silver in the vein. There is, therefore, evidence that silver was deposited at two different periods in the history of vein No. 64. The subject of secondary silver is further dealt with on pages 39 and 40 of this report.

In places the vein contains much iron sulphide now altered to limonite. At one place on the level, the fault breccia is so soft that it has fallen down slowly from the back of the drift for 20 or 25 feet.

The ladderway, referred to above, leading from the second level to the sub-level, was examined. It shows a vein almost vertical, but dipping about 80° south. On the sub-level this vein is three or four inches wide. It apparently runs into the fault 15 or 20 feet below the sub-level, the exact distance not being determined on account of the timbers.

Second Level.—(Elevation above sea level 826 feet at shaft No. 64.) The fault on this level consists of one to two feet or more of fault breccia, on each side of which is a gouge an inch or less wide. The gouge consists of clay and finely-crushed rock. The vein rests on the upper gouge of the fault; it is, in places, two feet wide. It consists mostly of calcite, but there are veins of smaltite or niccolite. If the vein is followed along the drift, it will be seen that in places it leaves the fault and runs parallel with it, at a distance of two or three feet to the south.

Here and there in the fault, as on other levels, there are rusty streaks which probably resulted from the decomposition of iron pyrites, galena, or zinc blende.

At the west end of the stope on this level there is an excellent place to examine the vein and the relation of the vein to the fault. Here the party wall between the Nipissing mine and the Hudson Bay mine was still left standing in August, 1921. The fault may be seen dipping steeply to the south. Rising vertically from the fault there are three or more veins of smaltite and niccolite (Fig. 14). It was not ascertained how high these veins rose, but on the Hudson Bay side of the wall one of them could be seen to rise 40 or 50 feet above the fault. A curious vein of smaltite or niccolite occurs in the fault breccia, crossing from the gouge on the upper side of the fault breccia, down through the fault breccia itself to the gouge on the footwall of the fault breccia.

Running north of vein No. 64, there is a long exploratory crosscut, 1,200 feet in length, which runs to the north end of the Nipissing boundary. The writer did not examine the north part of this crosscut. In a crosscut, 450 feet north of vein No. 64, a light-coloured grey felsite was met with at the west end. A fault was encountered in this west crosscut dipping 21° to the east.

Eighty feet north of vein No. 64, in the long crosscut referred to in the above paragraph, there is a fault striking apparently a few degrees north of west. This fault may be the eastward extension of "Y" fault on the third level of the Hudson Bay. Twenty feet farther north of this fault there is another similar fault which may correspond to fault "X" on the third level of the Hudson Bay. Both faults have a foot or two of fault breccia and fractions of an inch of gouge. They appear to be branches of fault No. 64.

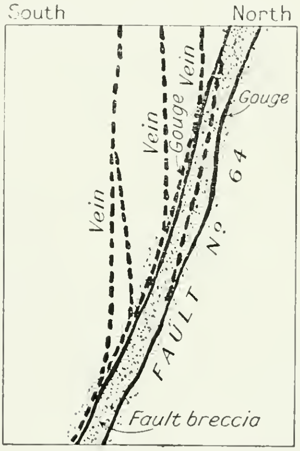


Fig. 14—Sketch, idealized, showing relation between fault No. 64 and veins; Nipissing mine, shaft No. 64, second level, west face of stope on boundary between Nipissing and Hudson Bay mines.

First Level.—(Elevation above sea level 918 feet at shaft No. 64.) There has not been much work done on this level; the vein has been drifted on for about 200 feet, and there is one short crosscut. No stoping has been done. The vein in the west part of the drift varies in width from a few inches to a foot; it averages about six or eight inches in width. A few feet east of the shaft, the vein pinches out, and from there to the east end of the drift, a distance of 90 feet, there is no vein exposed. In this barren area, the fault breccia has a width at one place of nine feet, with a gouge at each side of the fault breccia an inch or two inches wide.

Near the west end of the drift, at a crosscut, there is a pink calcite vein, a few inches wide, north of the fault about two feet. In places there is much rusty material in the fault. This rusty material probably results from the decomposition of iron pyrites, galena, or zinc blende.

In the shaft about 30 feet below the first level, there is a bed of slate about 13 feet, more or less, thick; timber in the shaft prevented our obtaining its exact thickness. The bottom of the bed of slate is 30 feet below the level.

Meyer Vein-System, and Veins 544, 490, 80, and 100

These veins are worked almost entirely from shaft No. 73. A description of the workings, beginning with the lowest, the ninth, may now be given. Reference to sheet No. 31a-11, in the pocket at the back of the report, will make the descriptions more readily followed.

Ninth Level.—(Elevation above sea level 434 feet.) With the exception of the deep shaft on vein No. 64, the ninth level is the deepest on the Nipissing property in this area. The Cobalt series has a thickness of about 600 feet, which is the greatest known thickness in Cobalt. The level is reached by going to the bottom of the Meyer shaft, thence along the fourth level to winze No. 73-4014; thence down this winze 112 feet to what is known as the fifth level; thence southward along the fifth level about 750 feet to winze No. 544; thence down this winze 122 feet to the ninth level, which is 548 feet below the collar of No. 73 shaft.

On the ninth level, there are about 500 feet of drifts and crosscuts, mostly on vein-system No. 544, which is labelled on the geological plan as vein No. 73-92 and No. 73-97.

An interesting feature of the Keewatin floor is the fact that the floor dips to the west, whereas on the west part of this area on higher levels the Keewatin floor dips to the east. There is, therefore, a valley, or depression, in the Keewatin floor in this area, the axis of which strikes a few degrees east of north. The depression may be due, in part, to folding.

The vein strikes about parallel to the axis of this Keewatin valley, that is, a few degrees east of north. The vein is not a wide one, possibly averaging an inch or two, mostly of pink calcite. At the north end it contains considerable niccolite. There has been no stoping on this level. The vein is one of the deepest veins occurring in the Cobalt series in the entire camp.

There are at least five faults on the level. One of these appears to be important; this one occurs at the station and seems to almost parallel the strike of the contact between the Keewatin series and the Cobalt series, namely, a few degrees east of north. It dips at angles of 57° to 67° eastward. The fault contains a vein of pink calcite and quartz two or three inches wide, in places six inches or more wide. The only place at which we could obtain a hint as to whether the fault was normal or reverse was in a crosscut 95 feet south of the winze, running eastward. Here the fault may be seen dipping 61° eastward. Broken rock largely filled the crosscut at the time of examination, but it appeared from what could be seen of the fault that it is a reverse one. Judging from the dip of the bedding on this level and the level above, the displacement is 20 to 25 feet, approximately.

In addition to this fault, there are four other faults, one of which is shown on the plan. These four faults do not appear to be as important as the one described above. The fault at the north end of the workings dips at an angle of 42° to 48° to the west; it intersects the vein above the level, but does not appear to fault it. On account of these faults the rocks on this level are crushed and altered, making it difficult, around the winze, to determine accurately the contact between the Keewatin and conglomerate of the Cobalt series.

Eighth Level.—(Elevation above sea level 481 feet.) Vein-system No. 544 on this level has yielded a little ore, whereas it had not been a producer on the ninth level up to August 11th, 1921. The vein at the south part of the drift follows a fault dipping steeply eastward, but, at a distance of 85 feet south of the winze, at a crosscut, it leaves the fault, the fault running into the wall.

At the south end of the fault, the rock is crushed for a width of two feet, but the crushed zone and gouge may average perhaps three or four inches.

In the crosscut at the south end of the workings, there is a bed of finely banded greywacké dipping southwest at an angle of 18°.

Vein No. 73-804, at the southeast corner of the level, has been stoped to a small extent and has produced a little ore. The stope apparently extends south to the party wall, and the veins may thus extend into the adjacent Right of Way claim on the south; it is a small vein.

Summing up the results of the work on the eighth and ninth levels, it may be said that these levels were made to explore vein-system No. 544; the output of silver therefrom has not been important. The general manager reported that ore occurrences in the vein were erratic and that two branch veins produced small quantities of good ore.[1]

Before describing higher levels it may be explained that there is no seventh level.

The sixth level is reached from winze No. 73-4014, about 750 feet north of winze No. 544, and will be next described.

Sixth Level.—(Elevation above sea level 511 feet.) The level consists mostly of a drift about 700 feet long on vein No. 490. The general manager reported in 1917 that the ore-shoot in the vein was 660 feet in length.

The Cobalt series forms a narrow belt running north and south and having a width of 30 to 70 feet.

An important fault, which has been named the "valley" fault, occurs on this level (Fig. 15). The fault strikes northward, and dips to the east at 59° to 77°. It is a reverse one, the rocks on the east side having been thrust up 75 feet, approximately.

Another fault occurs following the contact between the Keewatin and Cobalt series for some distance on the west; this fault dips eastward 38° to 60°.

The rocks are crushed and altered owing to these faults. For this reason the conglomerate and greywacké of the Cobalt series are difficult to separate from the Keewatin. It was found necessary to examine many thin sections of rock under the microscope, and even then the contact shown on the geological plan must be considered approximate. If more thin sections were taken and more time devoted, it might be possible, perhaps, to determine the contact more accurately. At the extreme north end, the contact between the Keewatin and conglomerate of the Cobalt series occurs about 13 feet above the floor in a raise leading to the fifth level. In another raise, just to the south, the contact is about 25 feet above the floor.

South of the winze, in the stope, the vein could be examined in August, 1921. It is a wide vein, in places showing a width of 8 or 10 inches of smaltite and niccolite. This vein occurs below the "valley" fault. It is younger than this fault, as will be explained presently.

About 11 feet below the sixth level there is a sub-level, consisting of a crosscut, which was flooded at the time of our examination. This sub-level was run some years ago, and little is known concerning it.

Fifth Level.—(Elevation above sea level 551 feet.) The level is reached from winze No. 73-4014. It is an extensive level, running north and south for about 1,800 feet, about paralleling the Chambers-Ferland boundary, in places a few feet distant.

Vein No. 490 has been followed for nearly 1,000 feet, and an ore-shoot 690 feet long disclosed, the vein assaying 800 to 1,000 ounces per ton across 5 to 6 inches.

---

[1] Annual Report Nipissing Mines Company, Limited, for year 1920.

At the southeast corner of the workings, a small stope has been mined in vein No. 73-567. This vein extends into the Chambers-Ferland.

The "valley" fault (Fig. 15) occurs in a crosscut opposite winze No. 73-4014. The rock east of the fault is Keewatin, and west of the fault Cobalt series. In the back of the stope, below the level, the writer examined the fault for a distance of about 300 feet, and found a fault breccia 6 to 10 feet wide, consisting of badly crushed rocks. In the stope, the fault dips eastward at about 60°. Keewatin rocks appear to be on the east side of the fault, and Cobalt series on the west; but the rocks are so badly crushed that difficulty was found in distinguishing them. As on the level below, it is evident on the fifth level also that the "valley" fault is a reverse one, the Keewatin having been thrust over the Cobalt series about 75 feet (Fig. 15).

There is another fault, at the station of winze No. 73-4014, dipping 36° eastward. This fault gradually joins the "valley" fault some 20 or 25 feet below the level. Vein No. 490 passes through this fault (Fig. 15).

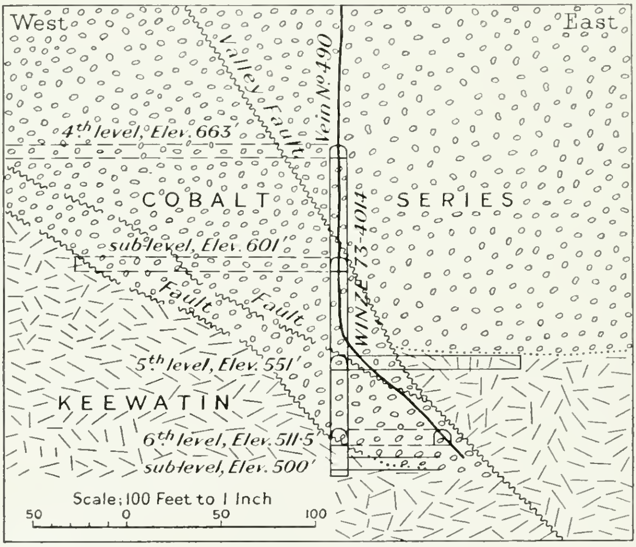


Fig. 15—Vertical section through vein No. 490, Nipissing mine, north of Cobalt lake, showing "valley" fault, and vein No. 490 passing through fault.

The age relation between the "valley" fault and vein No. 490 is shown in winze No. 73-4014, about 65 feet above the fifth level. The vein passes through this fault without having been faulted. Therefore, the vein is younger than the fault, as it has been shown that the displacement along the fault is at least 75 feet (Fig. 15). If the vein were older than the fault, it would have been faulted 75 feet.

Vein No. 490 is about vertical until it descends to within a few feet of the fifth level, when it flattens out and about follows the same dip as the "valley" fault (Fig. 15).

At the south end of the workings, west of winze No. 544, there is a bed of finely-bedded greywacké, 30 or 40 feet thick, which forms a horseshoe-like structure. The structure is suggestive of a syncline due to folding, as the bottom of the syncline shows the greywacké to be crushed and contorted for 15 or 20 feet or more. It may be that this bed conformed to a valley in the Keewatin, which strikes east of north, and that the bed was slightly folded, the folding following the axis of the valley.

The contact between the Keewatin and Cobalt series is exposed in the workings south of winze 73-4014 in three crosscuts. There is a well-defined fault at or about the contact. In one of the crosscuts this fault is followed for 140 feet; the fault here contains a vein of pink calcite and quartz up to 8 or 10 inches wide, immediately below which is a striking seam of blue clay a fraction of an inch to an inch wide. The fault dips at an angle of 34° to 40° southeastward.

Sub-level between the Fifth and Fourth Levels.—(Elevation above sea level 601 feet.) This level, which is reached from winze No. 73-4014, was also mainly used to develop vein No. 490.

The general plan of the level consists of a crosscut about 1,500 feet long, with a northerly but variable strike. It parallels the Chambers-Ferland boundary in a general way. It roughly parallels the Keewatin contact to the west; there are several east-west crosscuts running out to the contact.

Vein No. 490 may be seen at the winze and in three crosscuts south of the winze. In the first of these crosscuts south of the winze, the vein consists of about 5 inches of niccolite and some native silver. The "valley" fault is also exposed in three crosscuts. The vein apparently crosses the "valley" fault about 25 feet south of winze No. 73-4014. This fault south of the winze shows 2 to 3 feet of crushed rock and a gouge an inch or two wide.

Another fault, dipping 29° to 49° eastward, follows roughly the contact between the Keewatin and Cobalt series, and in places contains a vein of barren pink calcite and quartz, one to eighteen inches wide. North of the winze the fault turns northeastward and splits at the northeast end.

At the north end of the crosscut, the fault known as No. 64 was met with. It dips at 70° southward, and is about on a line with No. 64 fault disclosed in the workings from shaft No. 64. The fault consists, beginning on the south side, of the following: (1) six inches of soft, decomposed crushed rock fragments, with reticulating stringers of calcite fractions of an inch wide, together with stringers and disseminated grains of galena; (2) one and one-half to two inches of almost pure galena and a little copper pyrites; (3) eight inches of material similar to No. 1; (4) fifteen inches of slightly crushed rock; (5) two to six inches of crushed rock cemented with calcite stringers.

The rock on the north side of the fault is Keewatin felsite, and on the south side the Cobalt series. It is thus seen that the fault is a normal one in which the rock on the south side has been faulted down, how much is not known, but elsewhere in the mine the displacement is 10 to 25 feet.

Fourth Level.—(Elevation above sea-level 654 feet at shaft No. 73.) This level has developed the Meyer vein and its several branches The level is connected with vein No. 64 at the north part of the workings. Vein No. 490 has been explored by a drift for 350 feet at the southeast part of the workings, but the vein has not been productive on this or levels above because the level is too high above the Keewatin contact.

The level shows the main Meyer vein extending into Keewatin and following, at the south part, a bed of Keewatin "iron formation" which consists of black slate and chert. The vein was not productive in the Keewatin.

The most important branch of Meyer vein is No. 98 which continues northeastward and eastward, and extends into the Chambers-Ferland a short distance, where it practically pinches out. Vein No. 98 has half a dozen branch veins leaving it on the southeast side, and three or four leaving it on the northwest side. The stope on vein No. 98 averages approximately 10 or 15 feet in width.

There are three important faults on the level, namely, (1) fault No. 64, striking eastward, at the north part of the workings, in which vein No. 64 occurs; (2) the "valley" fault, striking a little east of north, at the east side of the workings; and (3) a fault which roughly parallels the valley fault at a distance of 100 to 200 feet to the west; this fault towards the north gradually converges with the "valley" fault, until about 200 feet north of shaft No. 98 the two faults are only 10 or 12 feet apart. At the south end of the workings this third fault follows the contact between the Keewatin and the Cobalt series for 300 feet, more or less, but towards the north it gradually leaves the contact until, at the north end, it is about 330 feet east of the contact. In places a vein of barren pink calcite and quartz is found in the fault; this vein is generally 2 or 3 inches in width, but in places as wide as 15 inches. This fault has been cut in a dozen places by drifts or crosscuts. It is of importance because it cuts off four of the veins, Nos. 420, 433, 419, and 426, which are southeastward branches of No. 98 vein. The stopes show how these four veins have been mined up to the fault, and are there cut off. Three veins have, however, been found above the fault; our examination did not determine whether or not these three veins were faulted portions of three of the veins below the fault.

The conglomerate on this level is remarkably coarse in many places, the boulders commonly being a foot or two in diameter. Quite often these boulders are seen on the floors of the workings, having fallen out intact from the sides or backs. Possibly one reason why the stopes in the Meyer vein-system are not wide, compared to certain Coniagas stopes, is on account of this coarse conglomerate. It was found on the Coniagas that the widest stopes are in the finer-grained conglomerate, not in coarse-grained conglomerate.

The contact between the Keewatin series and the Cobalt series shows a slight valley or depression in the Keewatin floor in one place. This depression occurs also on the level above, that is, the third level, on which level it is more pronounced. The Meyer system of veins appears to occur in the Cobalt series above this depression. Folding may, in some measure, have formed the depression.

Vein No. 64 has already been discussed in dealing with the workings from shaft No. 64.

Third Level—(Elevation above sea-level 734 feet at No. 73 shaft.) From this level have been mined the Meyer vein and some of its branches, and No. 64 vein at the north end of the workings. Vein No. 490 was intersected in a long crosscut, at the southeast end of the workings, and followed for a few feet, but it was not productive on this level.

The valley or depression in the Keewatin, which was described on the fourth level, also occurs on the third, and the Meyer vein-system occupies, in a general way, this depression. Folding may have caused the formation of the depression, or it may be partly due to a trough or depression in the original surface of the Keewatin, later somewhat deepened by folding.

The Meyer vein extends up to a minor fault plane (Fig. 13), immediately above which it was found at a distance of 40 or 50 feet westward. The vein has the appearance of having been normally faulted, 40 or 50 feet to the west. The fault dips at angles of 8° to 15° to the west. Where we were able to examine the fault it contained neither fault breccia nor gouge; scratches were noted in it striking westward, the direction of the supposed movement. The fault, however, has more the appearance of a strong joint plane rather than a typical fault. It contains in places a calcite vein fractions of an inch wide.

There is a possibility that the Meyer vein may not have been faulted; perhaps the fracture in which the vein was found extended down to this well-defined joint plane, and that, instead of continuing downward through the joint at that place, the fracture formed below the joint 40 to 50 feet eastward, and then continued down to the Keewatin.

Regarding these two points of view the writer must admit that he did not have an opportunity of examining the relationship of the vein to the supposed fault during the mining operations. The vein was mined out at the time of our examination. Those who were daily examining the working faces are best able to judge.

Vein No. 64 is described in that part of the report dealing with the workings from shaft No. 64.

Second Level.—(Elevation above sea level 816 feet at No. 73 shaft.) The second level is the most extensive level north of Cobalt lake, extending as it does almost the entire length of the property, about 3,700 feet. The workings connect with vein No. 64 at the north, with the Meyer vein at shaft No. 73, with vein No. 80 (the "Fourth of July") and vein No. 100. These two vein-systems, No. 80 and No. 100, were worked from No. 80 shaft. Vein No. 490 was also intersected in a long eastward crosscut, but it was barren, being too high above the Keewatin.

The workings from shaft No. 80 are about 29 feet below the workings from shaft No. 73.

At the station of No. 73 shaft, a prominent fault dips 21° to 30° southeastward; it has a vein of barren calcite about two inches wide, and some very red hematite. In the stope just west of the shaft above the level, the calcite vein in this fault is about 20 inches wide.

Vein No. 80 appears to pinch out in a few feet after it enters the Keewatin.

First Level.—(Elevation above sea-level 905 feet.) On this level the Meyer vein and veins Nos. 80 and 100 have been worked. The level is not an extensive one. The Keewatin does not occur.

The fault at the northeast part of the workings has been intersected in two places, in a drift and in a crosscut. The fault dips about 22° to 24° to the southeast and strikes northeastward. It consists of a fault breccia and gouge up to 12 inches or more wide. It cuts off a strong pink calcite vein which occurs at the northeast corner of the workings east of the Meyer shaft. This fault is shown on the map to connect with a fault which cuts the crosscut about 120 feet north of the "Fourth of July" shaft. It is not definitely known that the two faults are one and the same.

Veins No. 80 and No. 100 were originally worked from the "Fourth of July" shaft. They are the eastward extension of the No. 2 system on the Coniagas mine. They are now stoped out, but it was stated by the management that both veins were faulted, or apparently faulted, the parts of the veins above the fault having been moved some 4 or 5 feet to the northwest. The fault on which the movement took place is evidently the one described above.

Nipissing Mine Workings South of Cobalt Lake

The mine workings, grouped under the above heading, occur to the south and east of Cobalt lake. The plans are shown on Sheet No. 31a-13. The ore reserves in this area were in the year 1922 about one-half of the total reserves of the entire property.

Included among the important veins in this part of the Nipissing are No. 63 (Kendall), "Little Silver" vein-system, No. 251 (259), No. 96, No. 102, No. 109, and No. 99. These veins are south of the south end of Cobalt lake. Included among the important veins east of the lake are the following: No. 49, No. 122, and No. 26.

The company did not find it possible to keep a record of the ounces which each vein produced.

Vein No. 63, known as the Kendall, was considered to be the best vein found on the property up to the end of the year 1910,[1] but its output was subsequently far outstripped by the Meyer vein-system north of Cobalt lake.

The "Little Silver" vein-system was one of the first discovered in the camp in 1903. It has been an important producer.

The productive part of vein No. 251 (259) was discovered in 1921, and has developed during the last two years beyond expectations. The annual report of the company for the year 1921 states that the drift at the second level disclosed an ore-shoot 70 feet long with an average of three inches of ore assaying 3,500 ounces of silver. On the level below there is a continuous ore-shoot 265 feet in length, the vein showing two inches in width and an average assay of 2,900 ounces.[2]

In the year 1917, active stoping of veins Nos. 96 and 102 was begun, and results from this work were satisfactory and exceeded expectations.[3] Vein No. 109 in the year 1919 had been opened up on two levels and showed at that time ore reserves of 675,000 ounces of silver; the best part of the ore-shoot on the tunnel level assayed 6,800 ounces of silver over a width of 2.5 inches for a length of 80 feet.[4]

Vein No. 99 was found late in the year 1918; it is a comparatively small vein, but is rich.[5]

In the early history of the company, vein No. 49 was discovered and created much excitement and great hopes. It had an unusual width and was very rich. Unfortunately, the depth of the Cobalt series in the vicinity of the vein was shallow, and the hope that the vein would be a great producer was not realized. The records published in the annual reports of the company for the years 1908, 1909, and 1910 show that the vein during these years yielded 859,102 ounces of silver; the Ontario Department of Mines has no record as to what was the total yield of the vein.

Vein No. 122 was discovered in 1909, and the fracture was traced for about 900 feet; it was, however, only productive at the west end. During the years 1909 to 1914 this vein, together with Nos. 53 and 54, produced 1,958,711 ounces of silver, according to the records of the company; practically all of this output was obtained from vein No. 122. The ore of vein No. 122 was rich, the average value of the high-grade in 1909 being 5,600 ounces of silver per ton. A large amount of exploration work has been done on this vein, but much of the work was not productive of results. Work on the vein ceased in 1914.[6]

Vein No. 26, near the north end of Peterson lake, was one of the veins worked during the early days of the company. It produced about 1,500,000 ounces of silver; operations at the vein ceased in 1910. The workings were, however, dewatered in 1922 and operations resumed. The vein was entirely in the Keewatin basalt, and it was one of the few producers of the entire Nipissing property which was productive in the Keewatin. At the time of examination the workings were inaccessible. The stope section (Fig. 16) furnished by the company shows that the stope narrowed in length at the bottom.

---

[1] Annual Report Nipissing Mines Company, Limited, for year 1910, p. 11.
[2] Annual Report Nipissing Mines Company, Limited, for year 1922, p. 15.
[3] Annual Report Nipissing Mines Company, Limited, for the year 1917.
[4] Annual Report Nipissing Mines Company, Limited, for the year 1919.
[5] Ibid.
[6] Annual Reports Nipissing Mines Company, Limited, for the years 1909 to 1914.

At the time of our examination, in the year 1921, a number of other workings were also inaccessible. At the east side of Cobalt lake, the workings at No. 81 shaft and No. 128 shaft were not accessible. The workings east of Cart lake at No. 150 shaft and the workings west of Cart lake at No. 86 shaft were also inaccessible. The information regarding these inaccessible shafts, and workings connected therewith, has been obtained from the annual reports of the company.

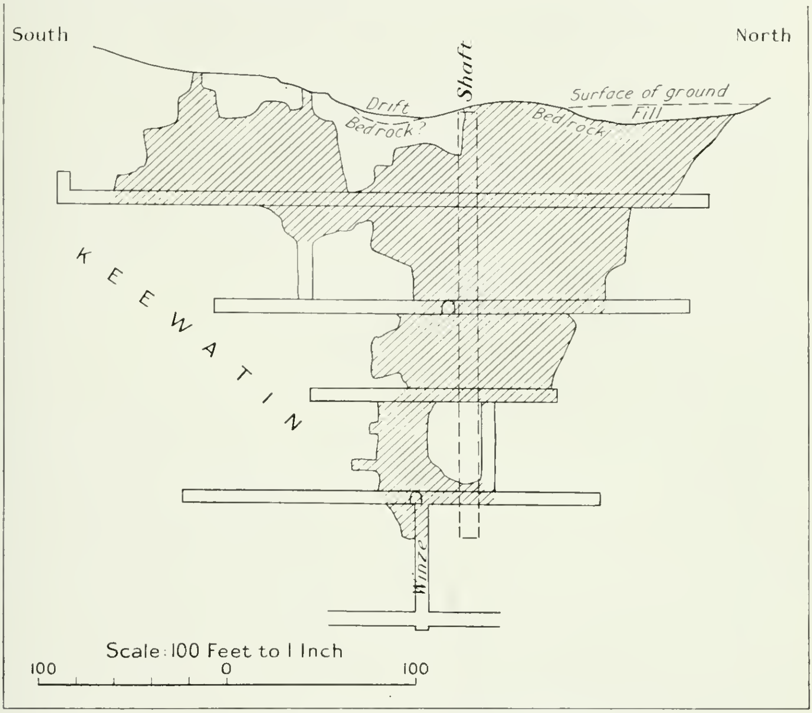


Fig. 16—Stope section of vein No. 26, Nipissing.

At shaft No. 81, near the east shore of Cobalt lake, considerable work was done on the Cobalt lake fault. Important ore-shoots had been found in this fault on the Cobalt Lake property, making it advisable to prospect the fault on the Nipissing property. The annual report of the company for the year 1916 states:—

> Shaft 81 was sunk to the Keewatin and crosscuts were driven at 425 feet and 520 feet below the collar. There is a strong vein along the fault, at times considerable cobalt, and occasionally some high-grade ore. These occurrences of rich ore, however, are scattering; nothing that can be considered an ore-shoot has yet been found.

The annual report of the company for the year 1917 states:—

> Development of the Cobalt lake fault continued throughout the year. An adjoining company found considerable ore in the fault just to the south of the boundary line. With the exception of a few tons of ore, however, no profitable values were discovered on the Nipissing side of the line. Some 4,200 feet of development work was done on the fault at 425 and 520 foot levels, including some exploration into the conglomerate at these levels. About 6,500 feet of work was done in the two years' operation at this shaft. It was discontinued in December [1917].

At shaft No. 128, also on the east shore of Cobalt lake and some distance north of shaft No. 81, development work was done in a basin of conglomerate, around the edges of which a number of veins were opened up on the surface. At the 120-ft. level of the shaft, 685 feet of crosscutting was done in various directions, but no ore was discovered.[1]

At shaft No. 150, on the east side of Cart lake, much prospecting was done in the Cobalt series. From the 209-ft. and 309-ft. levels, crosscuts were run in various directions, and several calcite veins were found and developed, but no ore was discovered in them.[2] The work proved that the Cobalt series had a thickness of about 300 feet. Operations were discontinued in the year 1915.

Shaft No. 86, at the west side of Cart lake, was inaccessible in 1921 and the writer has no information concerning the workings connected therewith.

Shaft No. 19, on Nipissing hill, was reopened in 1921 to extract the ore remaining in No. 6 open cut which had not been worked since the early days of the property. Vein No. 130 will also be mined through this shaft.[3] The group of veins (Nos. 6, 7, 129, 130, and 131) around shaft No. 19 has produced important quantities of silver from the Keewatin. The total silver yield from these veins did not, however, amount to as much as the output from vein No. 26, which was the largest producer from the Keewatin. Veins Nos. 12 and 40 yielded some silver from the Keewatin

Nipissing Mine Workings from Shaft No. 63

South of the south end of Cobalt lake, there is a valley or depression in the Keewatin which is now partly filled with sediments of the Cobalt series. This valley strikes southward, but towards the south end it broadens out and the east side of the valley strikes southeastward, as shown on the plan of the second level from No. 63 shaft. Cutting across this ancient valley, more or less at right angles to the strike of the valley, there are several veins, of which No. 63 (Kendall), the "Little Silver," and No. 251 are examples. Most of the veins extend up to, or into, the Keewatin on the west side of the valley, but only a few have been traced eastward to, or into, the Keewatin on the east side of the valley. The veins strike about eastward on the north part of the valley, but towards the south they strike more northeastward.

There is a reverse fault at the east side of the valley. The fault strikes about south-southeast and dips eastward 55° to 65°. The west side of the fault is the downthrow side, but the amount of the displacement is not known. The fault appears to be exposed on the surface near the narrows between Cart and Peterson lakes. It may be a branch of the Cobalt lake fault, although the two faults have not been connected by mine workings.

The veins occurring in this valley are worked almost entirely from shaft No. 63. The workings from this shaft, the second most important one in the Nipissing property, may now be briefly described, beginning with the bottom level.

Third Level.—(Elevation above sea-level 779 feet.) The level was flooded and inaccessible at the time of our examination in 1921. The workings, and the reported location of the veins, are shown on the plan.

Second Level.—(Elevation above sea-level 854 feet at No. 63 shaft.) This is the most extensive level from No. 63 shaft, the workings extending about half a mile in a north and south direction.

At the north end of the workings is the Kendall vein. It is about vertical where it occurs in the Cobalt series, but where it occurs in the Keewatin it dips southward about 58°. The vein follows, for part of its course at least, a minor fault. This fault contains a gouge and breccia as wide as five inches in places. At the east end the vein leaves the fault; where it leaves the fault, the vein becomes smaller and finally almost pinches out in 100 feet. The vein enters the Keewatin about 20 feet east of the shaft, and it was followed by a drift for about 190 feet west of the shaft. It was not productive in the Keewatin, although it is six inches wide in places, consisting of calcite and some aplite.

---

[1] Annual Report of the Nipissing Mines Company, Limited, for the years 1918 and 1919.

[2] Annual Report of the Nipissing Mines Company, Limited, for the years 1912, 1913, 1914, and 1915.

[3] Annual Report Nipissing Mines Company, Limited, for the years 1921 and 1922.

Vein No. 108 crosses the Kendall vein about at right angles. This vein also follows a minor fault, which contains varying amounts of gouge and fault breccia up to four inches wide at one spot, but in most places less than this.

Vein No. 148 is stoped, although the stope is very narrow.

Extending southeast from vein No. 148, there is a minor fault consisting of less than an inch of gouge and fault breccia. Here and there in it there is a little calcite. The fault is open for an inch or two; whether these open parts are due to a leaching out of the vein matter, or whether the fissure was never filled in these places, was not determined.

The next vein to the south is known as the "Little Silver" vein. On this level it splits at the west end and these two branches apparently pinch out as they enter the Keewatin. The east end of the "Little Silver" pinches out gradually until finally it is a joint crack with about an eighth of an inch of calcite in it. As the plan shows, the vein pinches out about 200 feet west of the Keewatin on the east side of the Keewatin valley.

About 150 feet south of the "Little Silver" vein, there is a vein-system of minor importance, Nos. 250 and 253.

Some 300 feet south of the last-mentioned veins there is another important group of veins, namely, Nos. 251, 254, 256, 259. In vein No. 251 (259), there was discovered in the summer of 1921 an important shoot of high-grade ore about 70 feet long and three inches wide, assaying 3,500 ounces of silver per ton. Since the writer examined this shoot in October, 1921, the level 55 feet below has been opened up and a shoot of ore in the vein disclosed having a length of 265 feet, a width of two inches, and an average assay of 2,900 ounces, according to the annual report of the company for the year 1922.

South of the last-mentioned group of veins there is another vein-system striking northeastward. The silver in these veins is reported to be erratically distributed and the production has not been large.

On the second level the basal conglomerate of the Cobalt series is, generally speaking, composed almost entirely of fragments of the underlying Keewatin. The contact between the Keewatin and the Cobalt series is therefore not sharply defined. It was, consequently, often difficult to decide as to where the contact should be shown on the plan. The contacts indicated on the plan should be regarded as approximate.

At the south end of the workings, the plan shows a bed of finely banded slatelike greywacké. The bed dips at angles of 10° southeastward, the steeper dips occurring near the southeast corner of the workings. It would appear that these steeper dips show that some folding has taken place in this area.

On the east side of the valley, opposite the "Little Silver" vein-system, a major fault was met with in two crosscuts. This fault is a reverse one, the Keewatin series having been thrust on top of the Cobalt series. The fault strikes south-southeast and dips eastward at 55° to 65°. There is a gouge one to two inches wide and a fault breccia of three or four feet, the Keewatin being more crushed than the conglomerate. An irregular vein of barren pink calcite and quartz occurs in the fault. This vein pinches and swells, and is an inch or two wide. At the east side of the fault the Keewatin floor appeared at one place to be dipping about 20° westward.

First Level.—(Elevation above sea level 941 feet at No. 63 shaft.) The veins worked on this level include the Kendall, the "Little Silver," and Nos. 99, 102, and 109.

The Kendall has been stoped out on this level, except at the shaft where the vein was still intact in the year 1921, showing a width of four to five inches.

The "Little Silver" vein has a length of about 450 feet and has been stoped for about 200 feet. The stope averages about 15 feet in width, its widest portion being in the slate-like greywacké. At the east end the vein gradually pinches out, while at the west end it enters a fault in a gentle curve. When the vein enters the fault, it becomes barren of silver, as far as the writer could observe. The fault consists of an inch or two of fault breccia and gouge, together with some calcite which cements the rock fragments. The fault is almost vertical, dipping 80° northeastward. About 30 or 40 feet southeastward of the "Little Silver" vein, there is a parallel vein with a length of 250 feet. At the east end it also gradually pinches out, while at the west end it also gradually enters in a similar manner the fault just referred to.

The south end of the first level is not connected directly with the north end, but is reached through winze No. 102-13. The veins in this part of the level are Nos. 99, 102, 109, all producers.

The first level is characterized by the bed of slate-like greywacké, which in winze No. 102-13 is 35 or 40 feet thick. The bed dips eastward at angles of 7° to 25°, the steeper dips occurring at the south end.

It may be added that none of the workings on the first level extend far enough to the east to intersect the reverse fault which was found on the level below in two crosscuts.

Tunnel Level.—(Elevation above sea level 1,024 feet.) This level is reached from a tunnel, and it may also be reached from winze No. 102-13. There are two important veins on the level, namely, Nos. 96 and 109.

Vein No. 28 Tunnel

Vein No. 28 tunnel is one of the longest tunnels in the camp. It is about 150 feet south of shaft No. 81, and it extends southeastward for some 1,800 feet from the east shore of Cobalt lake. In 1921 the tunnel was accessible and we were able to examine it. The following notes concerning the tunnel may be of interest.

The Cobalt series, dipping northwestward at about 25°, occupies the tunnel, or adit, for about 120 feet southeastward from the mouth of the tunnel. In this part the vein is about an inch and a half in width and consists of smaltite and calcite. It occurs in a minor fault which contains less than an inch of fault breccia and gouge. On entering the Keewatin, in which series the remaining part of the tunnel was run, the vein pinches out, but the fault appears to extend southeastward almost to the end of the tunnel, although it leaves the tunnel in one place, only to appear again towards the southeast end. The fault, where it occurs in the Keewatin, is about vertical and contains one to two inches of fault breccia and gouge. It has, here and there, lenses of calcite and quartz, fractions of an inch in width, together with a little smaltite, cobalt bloom, and nickel bloom.

About 625 feet from the portal of the tunnel, there is a crosscut striking southwestward; in this crosscut, about 60 feet from the tunnel, there is a calcite vein three or four inches wide carrying galena, zinc blende, and copper pyrites. The next crosscut to the southwest has a vein of calcite in it several inches wide; the vein is in a minor fault.

MINING CORPORATION

The Mining Corporation of Canada, Limited, owns the Buffalo, City of Cobalt, Cobalt Lake, Townsite, and Townsite Extension properties at Cobalt, and also several properties in South Lorrain, chief of which are the Frontier and Crompton. The Buffalo was bought in the year 1919 and is operated under the name of the General Examining and Developing Company. The Mining Corporation leased Peterson and Cart lakes in the year 1922, and in 1919 leased the Foster mine.

The Frontier and Crompton mines are described in that part of the report dealing with South Lorrain.

In recent years the Mining Corporation has made an energetic search for properties of merit. The company's campaign has taken its mining engineers into the farthest corners of the earth. China, Russia, Nicaragua, Bolivia, Chile. Peru, Mexico, and the United States have been searched. The company finally succeeded in May, 1921, in acquiring a majority interest in the Flin Flon mine in northern Manitoba. The engineers report that there are in this mine 16,000,000 tons of assured ore averaging 1.82 per cent. of copper, together with 1.16 ounces of silver per ton and $1.60 in gold per ton.

The Mining Corporation of Canada, Limited, has a capital of 1,660,050 fully paid shares of a par value of $5.00 each. To the end of the year 1922 the company had produced 34,906,491 ounces of silver. The number of fine ounces of silver which each property produced is given in the following table.[1]

PRODUCTION IN OUNCES BY MINING CORPORATION OF CANADA, LIMITED, FROM TOWNSITE, CITY, COBALT LAKE, AND BUFFALO MINES

	Townsite	City	Cobalt Lake	Total	Buffalo	Total
Prior to 1908	53,743	64,873		118,616		118,616
Year ended Dec. 31, 1908	94,926	538,590		633,516		633,516
" " " 1909	25,918	416,336		442,254		442,254
" " " 1910	200,707	271,258		471,965		471,965
" " " 1911	832,381	242,745	701,876	1,777,002		1,777,002
" " " 1912	1,494,029	210,650	1,123,147	2,827,826		2,827,826
" " " 1913	2,754,042	56,763	973,913	3,784,718		3,784,718
Jan. 1, 1914 to Mar. 31, 1914	407,663	105,303	353,656	866,622		866,622
April 1, 1914 to Dec. 31, 1914	1,621,449	691,024	872,651	3,185,124		3,185,124
Year ended Dec 31, 1915	1,963,540	1,023,865	1,576,551	4,563,956		4,563,956
" " " 1916	1,737,959	1,742,954	976,528	4,457,441		4,457,441
" " " 1917	1,996,549	2,181,106	307,887	4,485,542		4,485,542
" " " 1918				1,708,252		1,708,252
" " " 1919				1,230,653		1,230,653
" " " 1920				1,664,018		1,664,018
" " " 1921				495,512	731,205	1,226,717
" " " 1922				497,232	965,037	1,462,269
Total				33,210,249	1,696,242	34,906,491

The cost of producing silver in 1922 was $11.96 per ton, or 56.29 cents per ounce, based on a production of 23,404 tons which produced 497,232 ounces of silver. At the Buffalo the cost was $7.39 per ton, or 46.32 cents an ounce, based on a production of 62,218 tons which produced 965,037 ounces of silver. The table below gives a summarized statement of costs.[2]

---

[1] Ninth Annual Report of the Mining Corporation of Canada, Limited, for year 1922, p. 11.

[2] Ninth Annual Report of the Mining Corporation of Canada, Limited, for year 1922, p. 12.

Summarized Costs, Mining Corporation, 1922

	Labour	Material	Other	Total	Per ton	Per oz.
Mining costs	$54,975.83	$19,779.36	$8,561.45	$83,316.64	$3.56	cents 16.76
Milling and reduction (mine ore)			63,725.14	63,725.14	2.72	12.82
Milling and reduction (tailing)			85,548.49	85,548.49	3.66	17.20
Freight and realization (including selling and smelting charges)			27,456.60	27,456.60	1.17	5.52
Administration and general	8,868.65	2,508.35	8,450.12	19,827.12	.85	3.99
Total	$63,844.48	$22,287.71	$193,741.80	$279,873.99	$11.96	56.29
General Examining and Developing Co., Ltd., Buffalo mine, total cost	$115,582.38	31,656.34	250,196.47	397,435.19	5.83	41.18
Total	$179,426.86	$53,944.05	$443,938.27	$677,309.18	$7.39	46.32
Head office, royalties, taxes, etc			84,198.09	84,198.09	.92	5.76
	$179,426.86	$53,944.05	$528,136.36	$761,507.27	$8.31	52.08

Ore Reserves

The ore reserves at the end of the year 1922 consisted of 19,585 tons of broken ore in the stopes, while the tonnage of possible ore in place was stated by the management to be problematical. In other words, the City of Cobalt, Buffalo, Townsite, Townsite Extension, and Cobalt Lake properties are so intensively prospected and mined that ore reserves are now at a low ebb. The favourable development, however, of the corporation's properties in South Lorrain has given the company much promising area to exploit.

Structure

The rocks at the Mining Corporation properties at Cobalt consist of the Cobalt series which rests unconformably on the Keewatin series. The Cobalt series has produced practically all the ore, although the east wall of the Cobalt lake fault vein, which yielded important quantities of silver ore, is Keewatin.

The thickness of the Cobalt series is variable. On the west it thins out and finally disappears. At the southeast corner of the Buffalo it has a maximum thickness of over 244 feet. On the east side of the Townsite it has a maximum thickness of over 385 feet, while at the northeast corner of the City of Cobalt it has a maximum thickness of over 346 feet. At the north end of Cobalt lake the series has a thickness of about 510 feet, as proved by a drill hole from the fifth level at the north end of the Townsite Extension; the location of this hole is shown on the plan of the fifth level of the Townsite Extension. At the base of the Cobalt series there is a conglomerate bed; this is followed by a bed of slate-like greywacké, then by conglomerate, then by a thicker bed of slate-like greywacké, and finally by conglomerate. The slate-like greywacké beds, which are called "slates" by the miners, are irregular and often pass gradually into conglomerate, so that it is difficult to map them. The beds are not continuous. The general outlines of the beds are, however, shown on the plans.

The Keewatin consists of basalt, interbedded with which are beds of "iron formation", consisting chiefly of finely banded chert together with slate, the beds resting almost in vertical attitude and striking a little south of east. They are cut by small dikes of felsite.

Lamprophyre dikes cut the Keewatin series. At the City of Cobalt shaft an intrusion of lamprophyre has by its presence obscured the position of the Keewatin "iron formation" which apparently extends eastward from the Buffalo mine.

The geological mapping of the Mining Corporation's properties was done almost entirely by Mr. James Hill, who was assisted by Mr. David Hill. The writer spent a few weeks going over their work, but the plans show the geology substantially as they mapped it. During the work the Ontario Department of Mines had the valued advice and criticism of Mr. Warren H. Emens of the Mining Corporation, who is more familiar with the geology of the company's properties than any other geologist.

Veins

As discussed elsewhere in the report, it may be again pointed out that many of the veins on the Townsite and the south end of the Buffalo, Cobalt Lake, and City of Cobalt properties occur above or near a depression or trough in the Keewatin series. This depression in the Keewatin may have been caused by erosion; or it may have been caused by folding after the Cobalt series was laid down. Possibly a combination of these two causes may have accounted for the depression. That is to say, there may have been an erosion valley in the Keewatin which was subsequently filled with sediments of the Cobalt series; folding, parallel to the axis of the valley, may have deepened the depression. Whatever is the cause of the depression, the fact remains that the veins referred to occur above or near this trough in the Keewatin.

The vein-system at the northeast corner of the City of Cobalt property is reported to have produced about 12,000,000 ounces of silver. The two most important veins in this corner are No. 24 and No. 32. The writer is indebted to Mr. W. F. Fancy, mine captain of the Mining Corporation, for the following interesting information regarding the discovery of this vein-system. In 1913 the quantity of known ore on the City of Cobalt property was small, and the company was diligently searching for new veins. At that time it was the custom of Mr. C. E. Watson, resident manager, and Mr. Fancy to spend certain afternoons together examining the old workings which had been operated by a former company. On the second level there was a long crosscut extending from the City shaft northward to the Coniagas boundary line. This crosscut had encountered no ore. One afternoon Mr. Watson and Mr. Fancy were examining the crosscut and Mr. Fancy noted a crack in the rock about ten feet south of the north end. He found a few specks of cobalt bloom in the crack. After a consultation as to the advisability of prospecting this crack, Mr. Watson instructed that a drill be started and that the crack be followed southeastward. The location of this crack is shown on the plan of the seond level of the City of Cobalt property on Sheet No. 31a-12. The crack was accordingly followed about 35 feet, where it met with a four-inch vein of smaltite running about at right angles to the drift. The vein was immediately sampled, but the result was disappointing. It assayed but four ounces of silver to the ton. When, however, the next round of holes was blasted the vein was found to assay about 1,500 ounces of silver per ton. The finding of this vein was the means of discovering the vein-system known as No. 24-No. 32, which is reported to have yielded about 12,000,000 ounces of silver.

The old company, which had previously worked the property, had diamond-drilled this part of the mine. The drill barely touched vein No. 29 at a barren spot. Afterwards, when the Mining Corporation was stoping this vein, the diamond-drill hole was found in the stope. Truly, luck often plays a vital part in the fortunes of mining companies!

Many of the veins in the Mining Corporation properties have a strike a little south of east. This is about the strike of the Keewatin "iron formation", as shown on the level plans. It would appear that the strike of many of the veins was governed, to a certain extent at any rate, by the strike of the "iron formation."

One of the interesting features of the veins in the company's properties is the occurrence of ore in the Cobalt lake fault (Fig. 18). The writer was not able to obtain a record of the quantity of silver which the ore-shoots in the fault produced, but it is reported to have amounted to at least a few hundred thousand ounces.

Regarding the ore in the Cobalt lake fault, Mr. D'Arcy Weatherbe, consulting engineer of the company for several years, has the following remarks to make:—

> The most important results attained during the year were those from exploration and development on the Cobalt lake fault. It follows the eastern boundary of the lake and has a pronounced dip to the eastward. During the past year [1915] a programme of very energetic development work was followed on this fault, consisting of three crosscuts from the old workings, each of which intersected the fault at lower levels than any on which it had previously been explored. From these intersections, three levels, the fourth, fifth and sixth, were driven for long distances northerly and southerly and several very rich ore-shoots were discovered and worked. The ore consists largely of argentiferous niccolite. In one stope the vein averaged about eleven inches in width, and at one point exceeded two feet.[1]

The various properties of the Mining Corporation are described below. Reference to Sheet No. 31a-12 in the map case accompanying the report will make the descriptions more readily followed.

BUFFALO

Prior to its acquisition by the Mining Corporation of Canada, Limited, the Buffalo Mines, Limited, had a capital of $1,000,000 in shares of a par value of $1.00 each; in 1918 the capital stock was reduced to $750,000. The Buffalo Mines before it was acquired by the Mining Corporation paid $2,787,000 in dividends, the last one paid being on May 28th, 1914.

The following account of the Buffalo mine is, in part, summarized from the notes of Mr. James Hill, who in 1921 examined and geologically mapped the property for the Department.

Veins

There are two main vein-systems, one at the south end and one about the middle of the property. These veins for the most part strike a few degrees north of west and dip at approximately 80°. Midway between the systems there are two parallel veins which carry fair ore.

The system at the south end of the property includes Nos. 3, 10, and 12 veins together with connecting networks. There is a continuous stope along this system having a length of 960 feet, not including branch veins. The stope on No. 10 vein extends into the City of Cobalt property. The greater part of the stope is five to seven feet wide, but at the east end, at No. 12 shaft, there is a large open cut, which is some 75 feet in width. The grade of ore in this system varies from point to point.

---

[1] Second Annual Report, Canadian Mining Corporation, for year ended March 31st, 1916. p. 32.

The system in the middle of the property includes veins Nos. 5 and 6, together with connecting network. Vein No. 5 has a stope 400 feet long, not including branch veins, and it continues into the Nancy Helen. The stopes are from five to seven feet wide. An open cut has been worked in this system.

Vein No. 21 is of interest as it is the only vein in the property that was productive in the Keewatin. The vein is near No. 4 shaft, and is stoped up from the third level nearly to the second. About one-half the stoping height is in the Keewatin. The vein was cut off in the conglomerate by a gently dipping joint plane in which there is a calcite stringer about one-quarter of an inch wide.

Faults

There are two vertical faults, one known as the galena fault and the other as fault No. 6 (Fig. 8). The galena fault strikes a few degrees north of west and parallels the vein-system known as Nos. 3, 10, and 12 at the south end of the property. No. 6 fault occurs in the middle of the property and parallels the vein-system known as Nos. 5 and 6. It also strikes a little north of west. The galena fault, as its name implies, carries galena. On the second level there were in places four inches of pure galena in the fault. The fault contains gouge and fault breccia having a combined width of one-half an inch to twelve inches. On the third level for 100 feet along the east end of the fault, the rocks adjacent to the fault are much crushed. The fault may be seen cutting the slate-like greywacké in the east end of No. 10 stope; it does not displace the bed, and no displacement of the beds was anywhere noted. At the east end of the fourth level, the fault dips 75° to the north, while at the west end on the third level it dips 75° to the south, but in general it is about vertical. It is of interest to note that the galena fault dies out in the City of Cobalt property before it reaches the Cobalt lake fault.

Fault No. 6 has a fault breccia and gouge from one-half to eight inches wide, probably averaging from one-half to one inch. The workings of No. 5 open cut were inaccessible, and therefore it was not possible to see how far the fault extended to the east. Where it crosses the contact fault, described below, there is in one place a fault breccia of about four feet.

In addition to the vertical faults described above, there are gently dipping faults which, in a general way, parallel the contact between the Keewatin and Cobalt series. Chief of these faults is that known as the "contact" fault. On the plan of the first level of the Buffalo, the contact fault is shown commencing at the north shaft; it strikes southward, passing about 175 feet east of No. 6 shaft and about 120 feet east of No. 4 shaft. It extends northeasterly into the Coniagas and Trethewey properties. The contact fault appears to be a reverse one, but it has not been possible to determine definitely the amount of displacement, owing to the fact that the fault more or less parallels the bedding of the Cobalt series, and parallels the contact between the Keewatin and Cobalt series. The fault dips from the surface to the third level at No. 12 shaft at an angle of approximately 25°; below this it dips in places more gently at 12° to 15°, following for a distance a bed of slate-like greywacké. In certain parts the fault dips at angles as high as 27° to 45°. Between the third and fourth levels it passes into the City of Cobalt mine. The fault breccia and gouge average perhaps an inch or two in width; north of No. 12 shaft on the third level the rocks are crushed in the vicinity of the fault, which in this part splits.

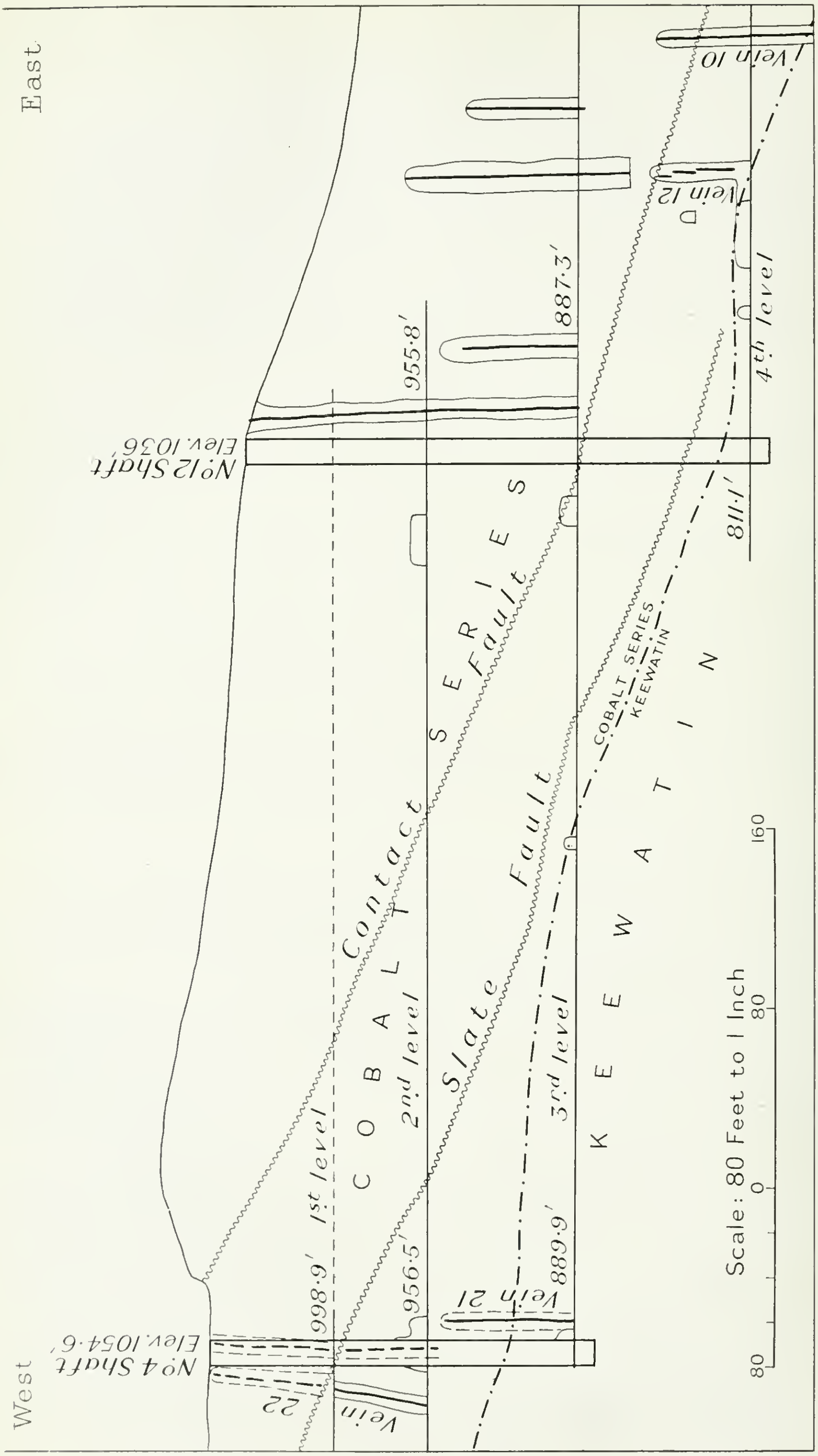


Fig. 17—Vertical section showing relation between the "contact" fault and veins, Buffalo mine.

Relation of Veins to Faults

The galena fault about parallels veins Nos. 3 and 10, and it appears to be older than these veins; the latter pass into the fault in places and do not appear to be disturbed by the fault. In the open cut in at least one place, the fault contained high-grade silver ore, some of the silver occurring in wire forms.

The age relation of the "contact" fault to the veins is puzzling.

Buffalo Mine Workings

There are five levels in the Buffalo mine, the lowest of which, the fifth, was not accessible at the time of examination in the latter part of the year 1921. The following notes regarding these levels may be put on record:—

Fifth Level.—(Elevation above sea level 785.9 feet.) The Mining Corporation furnished the Department with sufficient information to show the contact between the Cobalt series and the Keewatin series. The contact is shown striking east and west, parallel to which is a vein which splits at the west end. The vein and its branch are stoped.

Fourth Level.—(Elevation above sea level 811 feet at No. 12 shaft.) The Keewatin on this level consists of "iron formation" made up of finely-bedded chert and slate dipping about vertically, and impregnated with iron pyrites. The "iron formation" is cut by lamprophyre. The contact between the conglomerate of the Cobalt series and the Keewatin "iron formation" is sharp, although the surface of the Keewatin is jagged.

The feature of this level is the occurrence of a fault, which has been called by the miners the galena fault on account of the fact that it carries in places a galena vein a few inches wide. It also contains zinc blende and iron pyrites. The fault is in the same drift in which No. 10 vein occurs.

The fault consists, for the most part, of a gouge and breccia up to about a foot in width. In places there is in the fault a vein of smaltite and calcite carrying native silver. This vein may still be seen at the east end of the level, where it consists of about half an inch or more of smaltite and calcite with a clay gouge about half an inch wide on the north side and a fault breccia about ten inches wide on the south side. The vein is not disturbed or brecciated. At this point a parallel vein of smaltite occurs a few inches north of the fault, but this parallel vein is frozen to the country rock. At this end of the drift, No. 10 vein is a few feet north of the galena fault; in other places it is in the fault.

No. 10 vein at the west end of the level practically pinches out in the vertical beds of Keewatin chert or slate. The galena fault also appears to have pinched out when it reaches these chert and slate beds.

Third Level.—(Elevation above sea level 887 feet at No. 12 shaft.) The Keewatin series on this level contains the bed of "iron formation" consisting of chert and slate some 300 feet in width. This bed was encountered on the fourth level. It strikes westward, and the beds are in about vertical position. This "iron formation" bed is well exposed in the long crosscut running south from No. 6 shaft. To the north of the "iron formation" there is a bed of basalt 375 feet thick; while at No. 6 shaft an intrusion of lamprophyre and a small area of chert-like rock occurs.

East of No. 4 shaft a small intrusion of felsite appears to cut the "iron formation."

The galena fault is weaker in the Keewatin than in the Cobalt series. In the latter it has in places a foot of fault breccia. Some horizontal scratches were noted in the walls of the fault, indicating horizontal movement.

The contact fault has about three or four inches of fault breccia and half an inch of gouge.

Second Level.—(Elevation above sea level 955 feet at No. 12 shaft.) The junction of the galena and contact fault is exposed in the back of the drift at the south end of the workings. The contact fault appears to have faulted the galena fault about 18 inches, that part of the galena fault which is on the east of the contact fault having been moved to the north.

The contact fault on this level contains in places a vein of calcite and quartz up to two inches wide.

Fault No. 6, running southeast from No. 6 shaft, contains an inch or two of fault breccia and gouge.

In the southwest corner of the level there is a network of veins connected with vein No. 3 and the galena fault. In this area a bed of slate-like greywacké, four or five feet thick, rests almost directly on the Keewatin floor.

First Level.—(Elevation above sea level, 998.9 feet at No. 4 shaft.) This is the most extensive level in the mine, extending as it does from the north to the south boundary. The contact fault is shown to extend from the north to the south end of the level. At the south end it dips as steeply as 45° to the east; in places the fault breccia at this end of the mine is as wide as two feet. The contact fault apparently splits at the south part of the level. At the south end of the level the contact fault is over 500 feet east of the contact between the Cobalt series and the Keewatin series, but, towards the north, the fault converges closer and closer to the Keewatin until finally at the north end the fault is at the contact.

Vein No. 6 passes from the Cobalt series into vertical beds of "iron formation", the strike and dip of which it appears to follow.

CITY OF COBALT

The records of the Mining Corporation show that the City of Cobalt produced 7,545,461 ounces of silver during the years 1908 to 1917 inclusive. After the year 1917 the records do not show the separate production from the Townsite, City and Lake properties.[1]

As already stated in this report, the veins on the City of Cobalt consist of an isolated vein-system at the northeast corner of the property known as No. 24-No. 32 and of veins at the south end of the property, some of which are the eastward extensions of veins on the Buffalo and Townsite.

The interesting feature of the vein-system at the northeast corner of the City of Cobalt property is the extension of vein No. 32 through what has been called the "west" fault with little or no displacement. Regarding this occurrence, Mr. D'Arcy Weatherbe remarks:—

> The most interesting development at the end of the year 1917 consisted in the work on vein No. 32, which has, somewhat unexpectedly, been followed *through* the west fault, with apparently little or no displacement and was producing excellent high-grade ore.[2]

Mr. Weatherbe has described the vein-system at the northeast corner of the property in the annual report of the company for the year 1915, and his description is quoted below:—

> Vein No. 24 when first found, had a strike northwesterly and southeasterly but later on turned to the east, and a winze sunk from the 200-foot level intersected the Keewatin formation at about the 300-foot level. This winze proved the ore-shoot to be over 70 feet high at that point. On the 300-foot level the vein was followed for some 280 feet east of the winze. The

---

[1] Ninth Annual Report of the Mining Corporation of Canada, Limited, for year 1922, p. 11.

[2] Fourth Annual Report of the Mining Corporation of Canada, Limited, for year 19[illegible].

> ore was replaced by calcite but the Keewatin contact is dipping in that direction, and indications point to a probable continuance of the shoot on its pitch to the east below the 300-foot level. Northwest of the winze vein No. 24 is supplying some exceedingly rich ore, and another strong high-grade vein, similar in character to vein No. 24, and parallel to that portion of it northwest of the winze, has proved to extend northwesterly from the winze for about 130 feet. This vein is numbered 27. Meanwhile development to the west and southwest of the winze has proved an ore-shoot on a third rich vein, or system of parallel veins (No. 29), which also follows the Keewatin formation on its pitch similarly to 24 and 27. This ore-shoot, which approximates No. 24 in height, had been followed to the southwest of the winze for some 285 feet by the end of the year, and showed every indication of further extension in that direction. A somewhat obscure system of horizontal faulting intersects the whole rock containing these vein-systems and at places makes it difficult to follow the ore in the drifts. In the stopes, however, where the full widths of the ore bodies may more easily be exploited, the faulting appears to have had the effect of extending the silver deposition into the wall rock to such an extent that the stopes are occasionally carried to widths of 20 feet in pay ground. Development of branch veins and veinlets also tends to produce much larger quantities of ore than are at first apparent and in several cases indicate the possible existence of distinct high-grade ore bodies. The aggregate width of the high-grade ore from end to end of this vein system so far as exposed on veins 24 east of the winze and 29 west of the winze, will probably exceed 2½ inches and average in value over 2,000 ounces per ton.

The principal fault on the City of Cobalt property is known as the west fault. The location of the west fault is shown on the plans of the levels. If the west fault is the southward extension of the valley fault on the Nipissing, then it is a reverse fault with a displacement of some 75 feet. It has not, however, been proved that the two faults are one and the same.

The contact fault also occurs in the City of Cobalt property where it has been named the "reverse" fault on the plans.

It will be convenient in describing the workings of the City of Cobalt property to divide the property into two parts, namely, the south end and the north end. The south end includes the eastward extensions of the vein-systems on the Buffalo and Townsite. The north end deals with a distinct and important vein-system which has no connection whatever with the southerly system and is distant from it more than a quarter of a mile. The system at the north end has produced about twelve million ounces of silver.

South End of City of Cobalt

Fifth Level.—(Elevation above sea level 633.3 feet at City shaft.) This level is an important one from a mining point of view, since the electric haulage running from the south to the north end of the property is located here.

There are five parallel veins at the south end of the fifth level having the unusual strike of almost north and south—a few degrees east of north. The most westerly area is stoped out, and has at the south end a concrete dam which holds water up to the level above—the fourth. The stopes on this level, as far as we could see, are all narrow, some five to ten feet in width for the most part. Vein No. 31 is on the Townsite Extension.

The crosscut running east from No. 7 shaft on the Townsite is in Keewatin basalt. Conglomerate of the Cobalt series rests on the basalt, followed by a thick bed of slate dipping about 12° to 14° eastward.

The long drift and crosscut running north to the City of Cobalt shaft was unfortunately inaccessible, having been dammed. The location of the contact between the Keewatin and Cobalt series was obtained from Mr. Warren H. Emens of the Mining Corporation.

There appears to be a distinct valley in the Keewatin. The five veins referred to strike northward across this valley. A winze has been sunk on No. 31 vein, but it was flooded at the time of our examination.

There is a sub-level between the fourth and fifth levels.

Fourth Level.—(Elevation above sea level 701.7 feet at City shaft.) This level consists mainly of a north and south crosscut and drift paralleling the west boundary of the City of Cobalt. The main vein, No. 14, strikes a few degrees east of north. The stope is full of water, being held in by a concrete dam at the south part, referred to in the description of the level below.

The crosscut running north and south from the City of Cobalt shaft is partly in Keewatin "iron formation", but the "iron formation" is obscured by the presence of a lamprophyre dike which is somewhat schistose in places. The north end of the crosscut is basalt. In the crosscut running northwestward, opposite the City of Cobalt shaft, there is a rock containing fragments which consist largely of very fine-grained, greenish-grey material. There is, however, one rounded fragment of pink syenite about an inch and a half in width. The matrix of this fragmental-like material appears to be a lamprophyre. Certainly the south wall of the crosscut is lamprophyre.

The south part of the level was inaccessible at the time of our examination in 1921.

There is a ladderway, about 200 feet from the south end of the workings, by means of which it is possible to reach the sub-level below the fourth, and also to reach the fifth level.

Third Level.—(Elevation above sea level 758.3 feet at City shaft.) The galena fault on this level occurs about 40 feet south of the City of Cobalt shaft and it has been followed for about 200 feet eastward in a drift. No ore occurs in it, but in places there is a calcite vein less than an inch in width. The fault shows an inch or two of fault breccia and gouge. This drift appears to be in lamprophyre

What appears to be the contact fault may be seen in six places, the most northerly of which is at the City of Cobalt shaft at the station, where it is a weak structure and somewhat irregular, showing only an inch of fault breccia and gouge. Possibly its weakness is due to the fact that it occurs in the Keewatin at this point. Elsewhere on the level the fault shows from three to six inches or more of gouge and fault breccia. The fault strikes southwest and dips at 25° to 40° eastward.

The bed of slate-like greywacke on the level is resting in places, at unusually flat angles, dipping at as low angles as 7° to 8° eastward, but it also dips at angles as high as 15° to 20°.

The depression in the Keewatin on the third levels of the City of Cobalt and Townsite properties is well shown on the plans of the levels.

Second Level.—(Elevation above sea level 813.9 feet at the City shaft.) The second level is of interest on account of the fact that the vein-system known as No. 24-No. 32 was discovered on this level. The story of its discovery is given on page 65.

The galena fault extends about 100 feet east of the Buffalo. It appears to pinch out at the east end of the drift. The fault contains from an inch to two inches of fault breccia and gouge, although in places it is wider.

No. 10 vein of the Buffalo was, at the time of our examination, still to be seen in the party-wall between the Buffalo and the City of Cobalt; it is two or three inches wide. The vein is at the north side of the drift while the galena fault is at the south side, so that here the vein is not in the fault. In the stope, No. 10 vein made several jogs at horizons where it encountered well-defined joint planes in a bed of slate-like greywacké. This "jogging" of veins in the slate-like greywacké beds is of common occurrence at Cobalt (Fig. 25).

The contact fault, labelled "reverse" fault on the plan, has been followed 200 feet in a drift which about parallels the boundary between the City of Cobalt and the Townsite. The fault shows in places one-half to three-quarters of an inch of gouge and about 5 or 6 inches of fault breccia. In places the fault has a vein in it of the usual type characteristic of many fault veins, that is, of pink calcite and white quartz. This vein is up to 5 inches wide. The fault is well defined in this part of the workings. The contact fault is also well exposed on this level in a stope which is 100 feet east of No. 1 shaft on the Townsite. This is an important locality because it demonstrates that the fault is a reverse one. The reverse character is shown by the fact that the slate beds below the fault have been bent up.

Lamprophyre occurs at the City of Cobalt shaft. It also occurs at this shaft on the third and fourth levels.

First Level.—(Elevation above sea level 873.6 feet at city shaft.) The galena fault has been followed on this level for some 300 feet east of the Buffalo boundary line. At the east end it encounters a fault dipping about 35° to the southeast. The galena fault does not appear to extend east of this fault.

At the southeast side of the workings there is a bed of black and green slate dipping 12° to 15° to the southeast.

65-ft. Level.—(Elevation above sea level 945.6 feet). This is not an extensive level. Only one vein has been stoped, and this is an eastward extension of vein No. 10 on the Buffalo. There are a number of small veins of pink calcite in the crosscuts, but these have not been drifted on.

About 100 feet north of the shaft there is a fault dipping 35° to the south. It has been met with in the workings from point to point for 300 feet; it strikes northeastward, and shows 2 to 4 inches of gouge and breccia.

The crosscut running over 200 feet south of the shaft was not accessible. The entire level appears to be conglomerate of the Cobalt series.

North End of City of Cobalt

Fifth Level.—(Elevation above sea level 652 feet at winze No. 10, vein No. 32.) The north end of the level is reached by a long crosscut from shaft No. 7 on the Townsite. This crosscut, which roughly parallels the Keewatin contact, follows the right of way of the Temiskaming and Northern Ontario Railway; the right of way is known as the Townsite Extension. This crosscut intersects a well-defined fault named on the map the "west" fault; the fault has several inches of fault breccia and, in places, as much as an inch of gouge. It has not been proved that the "west" fault is the southward extension of the "valley" fault on the Nipissing.

The writer has been unable to obtain much first-hand information concerning the important vein-system at the northeast corner of the City of Cobalt property. The veins were about worked out at the time of our examination. The stope on vein No 32 is, in places, about 6 feet wide.

Where vein No. 32 extends west to the Keewatin, there is a fault at the contact of the Keewatin and Cobalt series.

Vein No. 24 extends westward into the Keewatin where it then follows a fault dipping about 65° southward. The fault contains one to five inches of fault breccia and a quarter of an inch or half an inch of gouge, but there is very little vein material in the fault.

The Department is indebted to Mr. Warren H. Emens for the following information regarding the drill hole at the north end of the level. The hole dips at 30° and parallels the right-of-way of the railway; it is 411 feet deep.

The Cobalt series occurs at a depth of 400 feet, beyond which Keewatin was encountered for 11 feet. The elevation of the top of the hole is approximately 661 feet above sea level.

Sub-level between Third and Fifth Levels.—This level is at varying elevations. It may really be referred to as the fourth level. A little of the Keewatin "iron formation" was noted. The plan shows the location of the veins and faults.

Third Level.—(Elevation above sea level 738.7 feet at winze No. 24.) This level is reached from the second level by way of winze No. 24. A bed of Keewatin "iron formation" occurs on this level, and the same bed was encountered on the two sub-levels below and on the fifth level. It consists of chert and slate finely banded.

Vein No. 24 pinches out at a minor fault, which contains about an inch of fault breccia. On this level the vein did not extend as far east as the "west" fault. The stope is 6 to 8 feet wide, but in places as wide as 10 to 20 feet.

Vein No. 32 extended through the "west" fault, and the vein has been stoped above and below the fault. The latter has a fault breccia of 3 to 12 inches wide, and a gouge from one-eighth to one-quarter of an inch wide.

Sub-level above Third Level.—(Elevation above sea level 761 feet.) The "iron formation" strikes southward, and it was found that vein No. 29 followed its strike and dip. The usual strike of the "iron formation" in the area west of Cobalt lake is a little north of west. Its southwestward strike on this level is unusual.

The west fault dips at an angle of 55°, which is much steeper than the dip on the fifth level. The vein went through the fault and was stoped above and below the fault.

Second Level.—(Elevation above sea level 813.9 feet at City shaft.) This is the level on which the important vein-system No 24-No. 32 was discovered. An account of how it was found is given on page 65 of the report. The west fault was intersected in two crosscuts. It dips at 40° to 50° eastward. In the long crosscut at the south end of the workings, a fault resembling the west fault was not found, but there are a number of eastward dipping faults at about the place in which the west fault should be, if its normal strike continues southward. Possibly these minor faults represent the west fault. In other words, the west fault may have split up into several branches at the point where the crosscut intersects it.

First Level.—This is really a sub-level about 70 feet above the second level. It is of no importance.

COBALT LAKE

The lower workings in the Cobalt Lake property are the deepest of any of the properties owned by the Mining Corporation at Cobalt. Most of the levels were, unfortunately, filled with water in the year 1921, the property not being worked at that time.

The returns to the Government show that Cobalt Lake produced 6,899,933 ounces of silver.

Cobalt lake was pumped out in 1915. The dewatering was commenced on April 19th, 1915, and was completed on June 5th. Two centrifugal pumps and motors of 3,500 gallons per minute each were installed on a pontoon in the deepest part of Cobalt lake. The water was discharged through a 20-inch wire-wound, wood-stave pipe line, 3,600 feet in length,[1] to Farr creek.

---

[1] Second Annual Report, Canadian Mining Corporation, for year ended March 31st, 1916, pp 27-28.

The principal veins consist of the vein in the Cobalt lake fault and veins No. 5 and No. 2. The two latter veins strike about eastward, but do not extend as far east as the Cobalt lake fault.

The vein in the Cobalt lake fault is of unusual width in places. On the second level from No. 4 shaft, it has a width of 4 feet in one place; in the stope above this level the vein has 15 inches of niccolite.

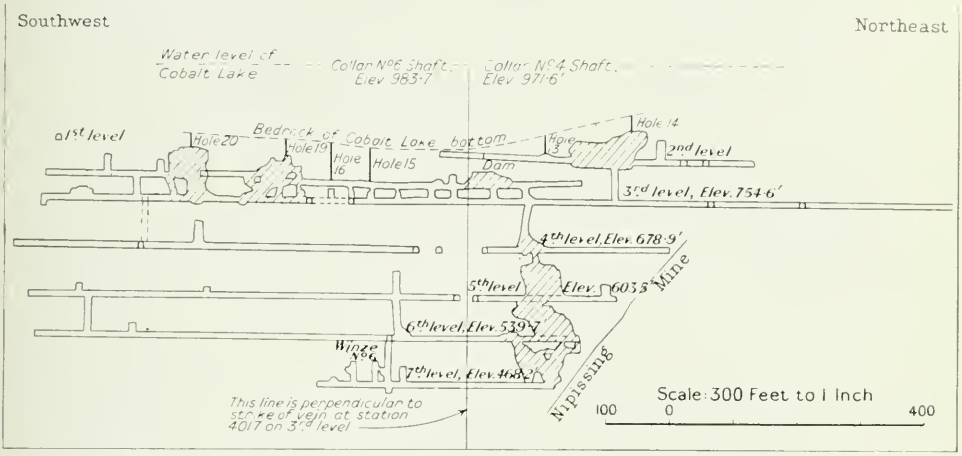


Fig. 18—Stope section in Cobalt lake fault vein, in Cobalt lake property (Mining Corporation). Furnished by the Mining Corporation of Canada, Limited.

Fig. 18 shows a stope-section of the vein in this fault. An idea of the richness of the ore may be obtained from the record of sampling which is shown in the table below. This information was kindly furnished by the Mining Corporation.

Much work has been done on the fault, and it has been found that over long distances the fault is lacking in vein matter. On the third level the fault has been drifted on for nearly half a mile.

WIDTH AND GRADE OF VEINS, COBALT LAKE FAULT

SIXTH LEVEL						FIFTH LEVEL		
Sample	Width	Assay	Sample	Width	Assay	Sample	Width	Assay
	inches	ounces		inches	ounces		inches	ounces
1	3¼	59.4	20	19	23.8	1	3½	178.4
2	7	86.8	21	8½	28.2	2	5½	846.1
3	4	68.4	22	7	22.4	3	10½	262.4
4	3½	122.8	23	8½	14.2	4	13	607.5
5	5	67.6	24	9	23.6	5	13½	863.3
6	12	51.7	25	7½	88.4	6	17½	1448.6
7	13	44.0	26	11	4453.8	7	18	1933.2
8	14	970.0	27	14	85.3	8	17	2990.0
9	9	0.5	28	6	1500.5	9	10½	2078.6
10	9½	0.5	29	9	455.0	10	11	2034.2
11	8½	28.2	30	9½	1198.6	11	9	976.8
12	7	0.5	31	8	601.4	12	7	1039.6
13	4	0.5	32	14	246.0	13	7½	1290.5
14	5	0.5	33	17½	537.8	14	13	749.6
15	6	0.5	34	16	1401.3	15	14	947.0
16	7½	0.5	35	6	1400.2	16	15	1249.8
17	4	0.5	36	5	305.6	17	14	515.8
18	5	8.4	37	3	162.4	18	12	80.9
19	8	18.5	38	12½	1789.9	19	8	264.4
						20	5	87.8
						21	5	60.0

Cobalt Lake Mine Workings

The fifth, sixth, seventh, and eighth levels were not pumped out in the year 1921. Hence no examination was made. The geology of the sixth level was, however, kindly furnished by the Mining Corporation. The extensive exploration work on this level represents a systematic and comprehensive piece of development. On the fifth level the contact between the Keewatin and Cobalt series is shown by a dotted line, this information having been furnished by the mining company.

Fourth Level.—(Elevation above sea level 678.9 feet at No. 5 winze.) The principal vein on the fourth level is No. 5. It is stoped out, and the stope is 5 to 12 feet wide and averages 10 feet wide in places. This vein-system pinches out before it reaches the Cobalt lake fault.

A well-defined fault, showing about 12 inches of fault breccia and gouge, occurs near the west end of No. 5 vein. The fault dips 26° eastward and is called the reverse fault. It is at the contact between a bed of slate-like greywacké and conglomerate.

The Cobalt lake fault has been drifted on for about 1,100 feet. In one place a crosscut was run through the fault at right angles to its strike. In this crosscut there is a fault breccia at least 15 feet wide, and the Keewatin is still crushed on the east face of the crosscut. The gouge is one inch wide. The rock in the fault breccia is schistose in places and the Keewatin is more crushed than the Cobalt series. On the west face of the gouge there is a vein of calcite 12 inches wide containing cobalt bloom. West of the vein there are 4 inches of rock, and west of the rock another vein consisting of 12 inches of pink and white calcite.

The Cobalt lake fault contains disseminated grains of cobalt bloom almost continuously along its entire stretch on this level; the width of the cobalt bloom is an inch or two, but in places it is 5 or 6 inches wide. The bloom occurs in or near the gouge. At the north end of the drift on the fault there is a vein of pure smaltite 3½ inches wide in places. This vein is exactly in the Cobalt lake fault; that is to say, it abuts against the gouge of the fault. Incidentally it may be remarked that no vein can be said to occur more exactly in the fault than one which rests against the gouge. It is along the gouge that the movement took place. In places the fault contains a calcite vein a foot or two wide; a little quartz occurs with the calcite.

Near the south end of the drift along the Cobalt lake fault, the fault splits; the east branch has been followed for about 50 feet, and it has a fault breccia 2 feet wide and a gouge about one-quarter of an inch wide.

Third Level.—(Elevation above sea level 754.6 feet at No. 5 winze.) The third levels of the Cobalt lake, Townsite, and City of Cobalt properties show particularly well the depression in the Keewatin series; and these levels also show how most of the veins occur in the Cobalt series above this depression. At the east side of the Townsite the depression is about 800 feet wide and about 125 feet deep.

The relation of the fault, called reverse fault on the plan, to the main vein may be seen in the stope. The vein has the appearance of being faulted 20 feet to the north by the reverse fault; that is to say, the part of the vein above the fault appears to have been moved 20 feet north. While the vein has the appearance of being faulted, there is a possibility that the vein came up to the fault and emerged above the fault 20 feet to the north; this possibility would simply mean that the vein is younger than the fault.

At the southwest end of the level, the Keewatin "iron formation" occurs. It consists of beds of chert and slate dipping steeply to the south. As shown on the plan, the bed of slate-like greywacké rests for some distance directly on the Keewatin "iron formation", there being no conglomerate between the greywacké and the "iron formation."

The Cobalt lake fault has been drifted on for nearly half a mile, and at the south end has a calcite vein in it as wide as 18 inches. In places smaltite and niccolite occur in the fault. North of No. 4 shaft a little cobalt bloom occurs in the gouge.

The gouge of the Cobalt lake fault is in places 4 or 5 inches wide; this is a most unusual width.

About 60 feet northeast of No. 4 shaft the Cobalt lake fault splits; the east branch has been followed a short distance and shows several inches of fault breccia, but little or no gouge. There is a calcite vein in the east branch from one-half to an inch and a half wide. This vein, which is called No. 3, splits into small stringers which barely come up to the Cobalt lake fault. A raise follows the vein up to the first level where the vein was productive in the Cobalt series.

Second Level.—The second level is reached from No. 4 shaft on the east side of Cobalt lake.

The southwest part of the level is reached by way of No. 1 winze from the first level from No. 6 shaft at the south end of Cobalt lake.

The workings from No. 4 shaft are of particular interest on account of the fact that it is one of the best places to show that a vein occurs in the Cobalt lake fault. This vein pinches and swells, and in most of the fault there is little or no vein material. One of the lenses is of extraordinary width, namely, 4 feet at the widest place; this lens is about 65 feet long and consists mostly of calcite, but shows in places 9 inches of pure niccolite. The characteristic feature of the lens is that it is banded.

Along the entire length of the drift the Cobalt lake fault has an almost continuous streak of cobalt bloom in or near the gouge.

In the back of a stope above the level, there is a vein of almost pure niccolite 15 inches wide in the Cobalt lake fault. A diamond-drill hole was drilled vertically upwards at this point, and it was found that there were 20 feet of rock between the back of the stope and the bottom of the lake.

The writer has not had an oportunity to examine all of the stopes in the Cobalt lake fault, but those he has examined show that the ore is in the fault.

No. 3 vein, which is a branch of the Cobalt lake fault, has 15 inches of calcite in one place. The calcite goes directly into the Cobalt lake fault.

That part of the second level at the south end of the property, which is reached by way of No. 1 winze from No. 6 shaft, is not of importance. The veins and kinds of rock are shown on the plan.

First Level, No. 6 Shaft.—The level consists of a crosscut following the boundary of the property. The crosscut intersects the Cobalt lake fault, which here shows a less disturbed character than is usual.

First Level, No. 4 Shaft.—No. 3 vein on this level has been stoped, and in one place in the back of the stope the vein contains 8 to 10 inches of smaltite. The vein occurs in a fault which appears to be a normal one, the south side having dropped down, judging from the attitude of a bed of slate-like greywacké. That is to say, the beds on the footwall are bent downwards.

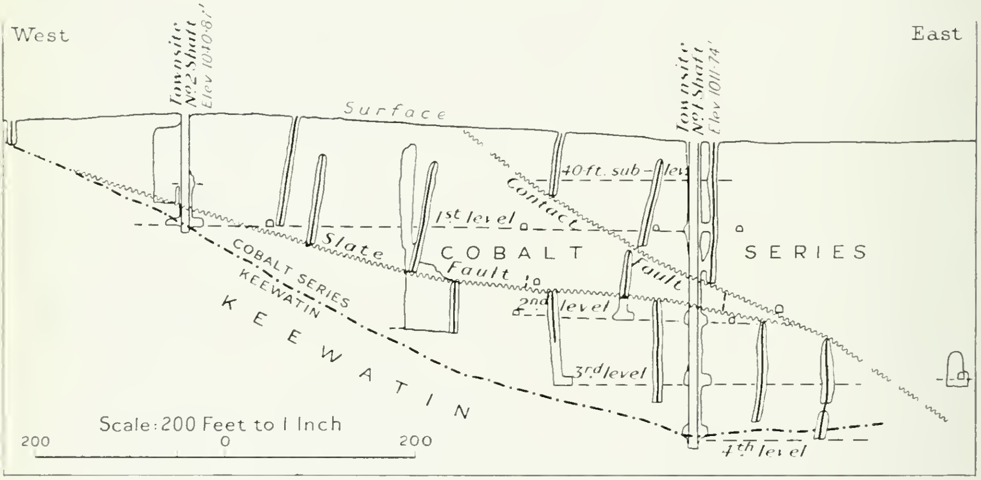
Townsite Extension

The Townsite Extension property consists of a long strip of land following the right of way of the Temiskaming and Northern Ontario Railway on the west side of Cobalt lake. The workings are described incidentally when dealing with the City of Cobalt, Townsite, and Cobalt lake properties.

Townsite

The Townsite property produced 13,182,906 ounces of silver during the years 1908 to 1917, inclusive. After the year 1917, the records of the Mining Corporation do not show the number of ounces of silver which this property yielded.[1]

The following description of the Townsite is taken substantially from the notes of Mr. James Hill, who examined and mapped the mine for the Ontario Department of Mines.



Furnished by The Mining Corporation of Canada Ltd

Fig. 19—Vertical section through No. 1 and No. 2 shafts, Townsite mine, showing relation of veins to "contact" fault and "slate" fault.

The Townsite property may be divided into two parts, namely, that operated from No. 1 shaft at the northeast corner of the property, and that operated from No. 4 shaft at the southwest part of the property. The levels from these two shafts are not at the same elevation. There are four levels connected with No. 1 shaft; there is also a fifth level from No. 7 shaft, but this fifth level consists merely of a short crosscut eastward to the City of Cobalt property. No. 4 shaft has two levels connected with it.

There are three faults in the property which are of importance. The first of these is known as the contact fault; this fault has been named on the plans the "reverse" fault. It is the southward extension of the contact fault on the Buffalo, and it dips eastward at angles of 25° to 40°.

Below this fault is one which follows the principal bed of slate-like greywacké; this fault has been called the slate fault, or slate slip, by the miners, and it dips southeastward at gentle angles. The contact fault and the slate fault are shown on the vertical section (Fig. 19). Both are reverse faults.

---

[1] Ninth Annual Report of Mining Corporation of Canada, Limited, for year 1922, p. 11.

Near the south end of the property there is a normal fault known as X fault with a displacement of about 21 feet. It dips to the southward at about 75°, the south side being the downthrow side. This fault is probably the eastward extension of the Clear lake fault. It follows a vertical bed of Keewatin "iron formation" from Clear lake eastward to the Townsite. The fault contains a vein of good ore; in places the vein is several feet from the fault.

Workings from No. 1 Shaft, Townsite

First Level.—(Elevation above sea level 917.8 feet at No. 1 shaft.) Vein A is 240 feet long and extends to the surface. It is cut off below by the contact fault, and is stoped to a width of 5 to 10 feet. The ore is reported to have been very rich.

Vein Q is 265 feet long, and is cut off between the first and second levels by the slate fault which follows a bed of slate-like greywacké. The stope has a width of 5 to 7 feet. It pinches out before reaching the surface. The ore was very rich.

Vein L west is 300 feet long. About 55 feet of this vein at the west end extends down to the first level. From No. 3 raise westward, the base of the vein rises with the Keewatin floor, and the ore rises to the surface. The width of the stope is about six feet, and the ore was rich. There is a net work of veins, connected with vein L west, which is cut off by the Keewatin floor or by the slate fault.

P vein is 210 feet long. It is cut off at the northeast end by the contact fault on this level, but it follows down below the fault. At its southwest end it pinches out. The vein is cut off below the second level by the slate fault. The stope is 5 to 6 feet wide, and the ore is reported to have been rich.

Second Level.—(Elevation above sea level 820.2 feet at No. 1 shaft.) Veins P and P west have a combined stope about 360 feet long and a width of 6 feet. Vein P west is cut off at the floor of the second level by the slate fault. The ore was high-grade.

The stope in Q and L veins combined has a length of 310 feet and a width of 5 to 6 feet. Q vein is stoped up to the slate fault; the south half of vein L is deflected at the fault, but it is still in the stope, and is stoped nearly to the surface. The remainder of L vein was cut off above by the slate fault; the vein is cut off below by the Keewatin floor. Vein Q is cut off 20 feet below the second level at the base of the lowest bed of slate-like greywacké. These veins afforded rich ore.

Veins S and S east have a combined stope 330 feet long and 5 to 6 feet wide. The top of this vein-system follows down the contact fault. Below it is stoped down to the slate fault.

Third Level.—(Elevation above sea level 756.8 feet at No. 1 shaft.) The stope in vein No. 14, vein S east, and vein S has a total length of about 480 feet. The stope has a width of 10 to 15 feet for a distance of 70 feet. This is the largest stope in the Townsite mine. Vein S was stoped up through the second level to the contact fault. Vein S east and No. 14 were cut off above by the slate fault. This vein-system pinches out at the fourth level near the Keewatin floor. Vein S had poor ore, S east had high-grade ore, and No. 14 vein had ore of fair grade.

The stope in vein R continues into the stope in vein G, and the two stopes together have a length of 290 feet. The average width of the stope is 5 to 6 feet. Part of the stope in vein R has a width of 10 feet for a distance of 30 feet. These veins are cut off above the third level by the slate fault, and continue downwards to the fourth level near the Keewatin floor.

The stopes in vein P west and vein P north have a combined length of 400 feet, and are 5 to 6 feet wide. These veins are cut off above by the slate fault, and they pinch out below near the Keewatin. Vein P west had high-grade ore, but vein P north was poor on this level.

Fourth Level.—(Elevation above sea level 702.1 feet at No. 1 shaft.) Vein No. 14 has a stope 380 feet long and 5 to 7 feet wide. It pinches out near the Keewatin. The stopes in vein G and vein R have a combined length of 200 feet and width of 5 to 7 feet.

Vein S has been stoped for 200 feet and the stope has a width of about 5 feet. Vein S and the net work of veins connected therewith are small and low-grade, and yielded mill-rock.

Faults

The contact fault strikes about north and south and is the southward extension of the contact fault on the Buffalo. On the first level it occurs about 100 feet west of No. 1 shaft and at the station of No. 7 shaft. It dips eastward at 35° to 37°. On the second level it passes into the City of Cobalt property; on the plan of the level this fault is named the reverse fault. On this level it dips eastward 25° to 30°. The contact fault has in places a fault breccia 1 or 2 feet wide. There are barren calcite veins in the fault, but these are never crushed. In the vicinity of No. 7 shaft on the first level, the rock is much crushed near the fault. There is evidence in the City of Cobalt property to show that it is a reverse fault.

The slate fault has been so named because it follows a bed of slate-like greywacké. In the northwest corner of the first level, the slate fault occurs at the top of a bed of slate-like greywacké. It dips with the greywacké at about 15° to the southeast. There is very little fault breccia or gouge in the fault. The location of the fault is shown on the vertical section (Fig. 19). The displacement along the fault is not known.

In addition to the contact fault and slate fault there are a few other faults, more or less parallel to the Keewatin contact; these are of less importance.

There are a number of almost vertical faults, the chief of which is known as "X" fault; it is probably the eastward extension of the Clear lake fault, and it follows a bed of Keewatin "iron formation." At the time of the examination in the year 1921, the best place to study X fault was in a raise in the fault above the second level. On the plan of the second level it may be seen that X fault, here named X vein, is at the extreme south end of the level. The fault strikes about west 20° north and dips at 75° southward. The south side has dropped down about 21 feet. This displacement may be accurately measured on account of the presence of a bed of slate-like greywacké. The fault breccia is up to 15 inches wide. Some horizontal movement has taken place along the fault, as the bed of slate-like greywacké in the hanging-wall is about one foot thicker than it is in the footwall.

On the second level a drift was run along the fault to prospect a calcite vein which occurs in the fault. The vein was not productive in this level, but was in the level above.

Structure of the Rocks

In the Keewatin rocks there is a depression or trough which strikes southeastward and is now filled with conglomerate, greywacké, and quartzite of the Cobalt series. The contour of the trough on the fourth level is, as the plan shows, horseshoe in shape, and it opens out into the old basin underlying the present Cobalt lake. The dip along the bottom of the trough is 15° to 22° southeastward. The dips of the beds of the Cobalt series are, Mr. James Hill believes, controlled by the slopes of the Keewatin floor; that is to say, the beds dip inwards towards the centre of the trough. As the trough was partly filled with conglomerate before the deposition of the slate-like greywacké, the dip of the slate-like greywacké bed is a little flatter than the dip of the floor of the trough, the slate-like greywacké dipping at angles of 6° to 20°, and the bottom of the Keewatin trough at 15° to 22° southeastward. Possibly, folding after the Cobalt series was laid down may have deepened the trough.

There are two beds of slate-like greywacké. The lowest bed, where it has been intersected by the workings on the fourth level, occupies about a third of the mineral area, and in two places it rests directly on the Keewatin floor; on the third level it occupies a small crescent-shaped area, and rests in one place directly on the Keewatin floor. On the second level it is only a thin bed of poorly-bedded sediments where it feathers out.

The second and higher bed of slate-like greywacké is in places about 16 feet above the first, and there is a bed of conglomerate between the two. This second bed of slate-like greywacké is 50 feet thick in "Q" stope, the thickness diminishing towards the surface and becoming thicker towards the southeast. This second bed covers about one-half the mineral area on the third level; while on the second level it forms a broad belt about 250 to 300 feet wide. On the first level it has narrowed down to a belt about 45 feet wide which almost rests directly on the Keewatin. It may be seen feathering out in L stope above this level. The lower part of this second bed is finely-banded greywacké, very fine in grain; higher up in the bed the sediments passes into quartzitic material which, however, has been included with the slate-like greywacké for mapping purposes.

A boulder of iron pyrites, 6 inches wide by 12 inches long, was found in the conglomerate on the first level of the Townsite. The pyrite was perfectly fresh.

Workings from No. 4 Shaft, Townsite

There are two levels from this shaft; part of the geology on the lowest level is shown.

The most important vein is known as "X" vein; it occurs in a normal fault having a displacement of about 21 feet, and containing fault breccia from 1 to 12 inches wide. On the first level the vein has been stoped for 380 feet, and on the second level for 470 feet. The stope has a width of 6 or 7 feet; in places barren calcite may still be seen from 8 to 12 inches wide. At the west end the vein consisted of smaltite 1 foot wide. In places the ore was rich. The vein is sometimes in the fault and sometimes in the wall-rock some 5 feet or more from the fault.

To the south of vein "X" on the first level, there are a number of other veins, chief of which is No. 8 which is stoped in places nearly to the surface. No. 8 vein is in or adjacent to a fault which has a fault breccia from one-quarter to two inches wide. The other veins south of vein "X" have for the most part been stoped only 10 or 20 feet above the level. The vein known as "X-6" produced fair ore; the other veins yielded about 10-ounce mill-rock.

On the second level there is a fault at the northeast end of the long crosscut running northeast under the railway track. This fault dips at 25° eastward, has a fault breccia and gouge 1 to 6 inches wide, and appears to line up with the contact fault.

CONIAGAS

The Coniagas Mines, Limited, has a capital of $4,000,000 in shares of a par value of $5 each. To the end of the year 1922 the company had produced 31,286,744 ounces of silver and had paid $11,140,000 in dividends.

The company was incorporated in November, 1906; concentration of ore began in September 24th, 1907; and mine ore and concentrates were shipped and treated together during 1907 and 1908.[1]

In January, 1920, the Coniagas bought the Trethewey mine and all the company's assets for $100,000. In 1922 the company leased the Beaver mine, and began operations thereon in January, 1923. The company in 1922 and 1923 were working under option the Ruby mine near North Cobalt.

In addition to its activities in and around Cobalt, the company is developing a gold property at Porcupine, and is interested in other gold claims elsewhere in Northern Ontario.

At the end of October, 1922, there were at the Coniagas mine about seven miles of workings, including drifts, crosscuts, raises, winzes, and shafts.

The company has been treating lower grade ore than any other company in Cobalt. For the year ending October 31st, 1922, the ore averaged 9.19 ounces per ton. The ore hoisted amounted to 123,583.8 tons, from which were received 1,121,279 ounces of silver. The ore was mined and concentrated during the year at a cost of 32.64 cents per ounce of silver content. This cost includes all overhead expenses, royalties, and other general expenses, but excludes the cost of smelting, refining, shipping and marketing, which amounted to 7.64 cents per ounce. The average cost of silver produced during the past 15 years, including all charges above mentioned, has been 23.87 cents per ounce.[2]

The low cost of operation is partly due to the immense width of some of the stopes, partly to the fact that mine and mill are encompassed within an area of but 17 acres, and partly to the excellent management.

It is interesting to contrast the grade of ore in the early days at the Coniagas with the grade at the present time. In the year 1907 the ore averaged $50 per ton; in the year ending October 31st, 1922, the ore averaged, as pointed out above, 9.18 ounces of silver per ton.

Almost the entire production of silver has come from the northeast part of the property from an area of ground about 17 acres in extent and about 200 feet in depth. The south half of the property has not been productive.

As may be seen from the plans, the veins on the Coniagas form a complex network; included among the big producers are Nos. 2, 18, and 28; of these veins No. 2 is the most important.

In the last few years very little high-grade ore has been found, and the mill has been treating low-grade mill-rock. In the year 1920, the mine produced only five tons of high-grade ore.

The ore has been obtained almost entirely from the Cobalt series, but a very small quantity was won from the Keewatin. The Cobalt series has an average thickness of about 200 feet, although at the west end of the property it pinches out entirely.

The stopes in the Coniagas are the largest in the Cobalt camp. Some of them are 40, 50, and 60 feet wide and, in one instance, that of the stope on vein No. 18, the stope is 85 feet in width. The great width of this stope is due to the fact that several veins join vein 18, and it is at the junction of these veins with vein 18 that the stope attains a width of 85 feet. Many of the veins in this stope were small, averaging not more than three-eights of an inch in width.

---

[1] Annual Report, Coniagas Mines, Limited, 1918, p. 11.

[2] Annual Report, Coniagas Mines, Limited, year ending October 31st, 1922, pp. 4-5.

It has been the experience of the Coniagas mine that the fine-grained conglomerate was more productive of ore of milling grade than was the coarse-grained conglomerate. No doubt the reason for this was that the fine-grained conglomerate was more readily fractured into tiny cracks than was the coarse-grained. The high-grade ore occurs as commonly in the coarse conglomerate as in the fine-grained. It is well to remember that the high-grade ore occurs only in the veins; these average about an inch or two in width. What has been called the low-grade ore, or mill-rock, is for the most part simply the country rock which is fractured into innumerable tiny cracks, into which silver solutions have penetrated, and along which the silver was deposited. The country rock is thus impregnated with silver for many feet on each side of the vein or veins, producing what is locally called mill-rock.

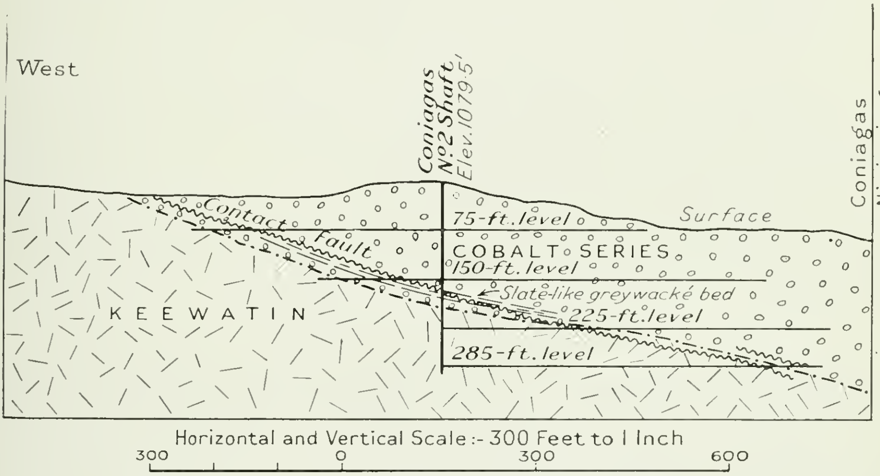


Fig. 20—Vertical section, west 23° north through Coniagas shaft No. 2, showing location of "contact" fault, and its relation to the Keewatin and to a bed of slate-like greywacké.

The "Contact" Fault

An important structural feature of the mine is the presence of a fault which is named on the plans the "Coniagas" fault. This fault is the northward extension of what has been called "contact" fault on the Buffalo. In the following description it will be called the contact fault. On the Coniagas it occurs, for the most part, about ten feet more or less above the Keewatin floor, although in places in the lower levels it passes down into the Keewatin. In other words, this fault is, generally speaking, about parallel to and a little above the contact between the Keewatin series and the Cobalt series; hence the name "contact" fault. The fault dips at an angle of about 16° in a vertical section through No. 2 shaft (Fig. 20). The dip of the contact between the Keewatin and the Cobalt series in the same vertical section is about 14°, or about 2° flatter than the dip of the contact fault.

Silver occurs, as a general rule, above and below the fault where the veins are in the Cobalt series. This statement may be substantiated even now, although the ore is mined out, by examining the great stope in vein No. 69. The fault may be observed on the sides of the stope, some 15 or 20 feet above the level, while above and below the fault it may be seen that the ore has been mined out. While it is true that the silver ore does occur above and below the fault, it has nevertheless been pointed out by the management that the character of the ore above the fault is different from that below. The management states that more high-grade silver ore occurs above the fault than occurs below; on the other hand, the rock below the fault was found to be a better grade of milling ore than the rock above the fault.

The displacement along the contact fault has not been determined nor has the direction of the movement. The age relation of the fault to the veins has also not been definitely determined, but it would appear that the veins are younger than the faults. One reason for this belief is that the ore below the fault is lower in grade than that above the fault. The writer had no opportunity to study this problem during the time that the veins were being mined along the fault. The same problem regarding the relation of the veins to the contact fault was met with in the properties of the Mining Corporation south of the Coniagas.

The Keewatin floor, on which the sediments of the Cobalt series were laid down, was remarkably uniform, as may be seen by examining the contours of the contact on the map of the Coniagas. Only at one place was much irregularity observed and that was on the 225-ft. level in the vicinity of No. 9 vein.

During May, 1921, the Coniagas mill was treating about 325 tons of ore per day from the mine; the ore contained about 10 ounces of silver per ton. In addition to this, the Coniagas mill was treating about 200 tons a day of tailings from the dump, the tailings containing about 3 ounces of silver per ton. The slimes on the property contain 6 or 7 ounces per ton, and were also being treated by the Coniagas Mines, Limited, but these slimes were treated in the Buffalo mill.

Coniagas Mine Workings

The Coniagas is worked mainly from No. 2 shaft, the elevation of which above sea level is 1,079.5 feet. The mine has 5 levels, namely, the 75-ft., 150-ft., 225-ft., 285-ft., and 375-ft. The lowest level, the 375-ft., is at the extreme southeast corner of the property, and is not connected directly with any shaft, but is entered by means of a winze from the 285-ft. level.

375-ft. Level.—The 375-ft. level was not pumped out at the time of our examination. Less than 200 feet of work has been done on it. The company states that the winze was in conglomerate and greywacké of the Cobalt series. In the crosscut which runs west of the winze, the Keewatin was said to have been encountered 15 or 20 feet west of the winze. The crosscut running northward is said to be entirely in conglomerate. There are no veins reported on this level.

285-ft. Level.—This level produced, relatively speaking, unimportant quantities of silver.

The contact between the Keewatin and Cobalt series may be seen in half a dozen places, and thus its contour is fairly well established. At the north end of the workings, there are two faults which are about parallel to the contact between the Keewatin basalt and the Cobalt series. One of these faults is about 15 feet above the other. The faults are evidently part of the contact fault which is so well developed on all of the higher levels. Possibly at this depth the contact fault has split into two parts, although we were not able to prove this. At the north end of the property, on a sub-level about 10 feet above the 285-ft. level, the most productive vein on the property, No. 2, has been stoped out. The floor of the stope follows about the contact between the Keewatin and Cobalt series on this sub-level. The west face of the sub-level is Keewatin, and it may be seen that No. 2 vein has pinched out on entering the Keewatin series at this point. Vein No. 65 has a width up to 3 inches of pink calcite; it is a strong-looking vein, but is unproductive as far as explored. A little stoping was done on a vein near the south end of the property.

The Keewatin on the 285-ft. level is a fine-grained basalt. No slate-like greywacké in the Cobalt series was observed on this level.

The only suggestion of the presence of the contact fault at the south end of the property is a calcite stringer dipping 21° eastward; this stringer is a few feet below the contact between the Keewatin and Cobalt series.

225-ft. Level.—On this level the contact between the Keewatin and the Cobalt series has been met with in several places. The contact fault has also been met with in several places; it is partly in the Keewatin series, but mostly in the Cobalt series. At the north part the fault takes a long bend eastward into the Cobalt series. It consists of fault breccia up to 6 or 7 inches wide, and, in extreme cases, a foot or two wide. The gouge is an inch or two wide. In places there is a pink calcite vein as wide as 6 inches in the fault. The fault may be very well studied in the south part of vein No. 69. This vein is located between No. 2 shaft and winze No. 23. We were not able, from actual observation, to determine the direction of the movement on the fault, or for how many feet the rocks had been faulted, nor were we able to determine the relative age of the fault and the vein. It was reported by the management, however, that vein No. 69 came down vertically to the Coniagas fault and that, on encountering the fault, the vein followed the fault down in step-like breaks, until at a distance of about 22 feet southeastward it again took a vertical course and continued down through the conglomerate. The management further reported that in this part of the fault some ore of economic grade was met with.

At the east end of vein No. 23, the fault bears an economic relation to the silver content of the vein; it was reported that no silver was found below the fault, although the vein occurs below the fault.

No well-defined bed of slate-like greywacké was observed on this level, but a poorly-defined bed, shown on the plan, was noted in drift No. 26. This bed probably corresponds to the bed of slate-like greywacké in the big stope on No. 69 vein and to the bed of slate on the 150-ft. level. Greywacké also occurs in crosscut H, about 500 feet from the entrance; it is not clearly enough bedded to make it possible to map.

Veins Nos. 18 and 12, at the north end of the property, apparently pinch out on entering the Keewatin, judging from what may be seen on the level. Vein No. 2, the most productive vein on the Coniagas, may still be seen on the face of the drift at the east end; the ore was not mined here because it is at the boundary of the Nipissing and Coniagas mines. No. 2 vein on the Coniagas is known as the "Fourth of July" vein on the Nipissing. The vein on the east face contains high-grade silver ore, and is about an inch and a quarter in width; the vein contains smaltite, calcite, and native silver. About 8 feet above the floor of the drift, there is a fault which is apparently the contact fault. The vein may be seen at the bottom of the face of the drift, and may be traced up the face about 5½ feet, where it pinches out. The point at which it pinches out is about 2½ feet below the fault. The vein, of course, appears again above the fault, but how far above we were not able to observe. Vein No. 22 at its eastern extremity pinches out to a crack in the conglomerate, and it also pinches out westward in the Keewatin to a mere crack containing calcite here and there about a thirty-second of an inch in width.

Vein No. 9 is interesting on account of the work which has been done on it; but this work was done in order to explore the vein in the Keewatin. The vein was followed in a drift in the Keewatin for 600 feet to the west boundary of the property. It was found to have a width up to 2 or 3 inches, but it did not contain enough silver to pay.

Vein No. 62 at the south end of the property has a width, where it may now be seen, of about half an inch of calcite; it is not a productive vein. Stoping was done at the south end to a height of 22 feet by about 25 feet long.

150-ft. Level.—This level has more work done on it than has any other in the mine. The feature of this level is the great size of stope No. 18, which in one place attains a width of 85 feet. The reason that the stope could be worked to such a width is that there are several veins running into the main vein, No. 18.

No. 9 vein was explored on this level well into the Keewatin series, and while it produced a small quantity of silver, we were not able to ascertain how much; it was, nevertheless, of little importance in the Keewatin. The contour of the contact between the Keewatin and Cobalt series is very regular.

About 10 or 12 feet above the base of the Cobalt series, there is a bed of slate-like greywacké some 8 or 10 feet thick. The bed may be traced on this level for about 700 feet, but we were not able to find a bed on the level below, the 225-ft., which would correspond to it. The bed does go down almost to the 225-ft. level, for it may be seen in stope No. 69 about 15 or 20 feet above the 225-ft. level. The bed was not recognized on the 75-ft. level.

On the 150-ft. level the contact fault follows the top of this bed of slate-like greywacké, except at the south end where it appears to pass down to the lower part of the bed and thence out of it.

Another bed of fine-grained cherty greywacké of a peculiar greenish colour was noted on the eastern part of the workings at veins Nos. 2 and 28. Its location is shown on the plan. This bed is not easy to separate from the other sediments of the Cobalt series; it is structurally about 75 feet above the bed which has just been described.

In July, 1921, the only development work which was being carried on was being done on the 150-ft. level at the south end of the property. A small vein about 35 feet northeast of vein 15 was being drifted on towards the southeast. At the end of the long crosscut near the southwest corner of the mine, another small vein was also being explored.

The south part of the Coniagas property is the only part which has not been thoroughly explored, hence the development work which was being done in July, 1921. The contact fault has been traced for a greater distance on this level than on any other. It has been followed for 1,100 feet, and at neither end had it pinched out. The fault consists of a fault breccia and gouge 4 or 5 inches in width; there is always more fault breccia than gouge in the fault. In places the fault breccia is 2 feet or more in width. Practically all of the 150-ft. level is accessible, except the last part of vein No. 2 and part of vein No. 18.

75-ft. Level.—Much of the level is inaccessible as the floors have been stoped out, and there is generally no timber to allow the examination of the parts so mined out. The contact between the Keewatin and the Cobalt series was cut only in one drift, that which follows vein No. 4. The contact fault, however, was encountered in five drifts and has been traced for 500 feet; the fault has not pinched out at either end.

KERR LAKE

The Kerr Lake Mines, Limited, has a capital of $2,400,00 in shares of a par value of $4. The company has produced 27,005,276 ounces of silver, and has paid $10,195,000 in dividends to the end of the year 1922. The property was closed on February 1st, 1922.

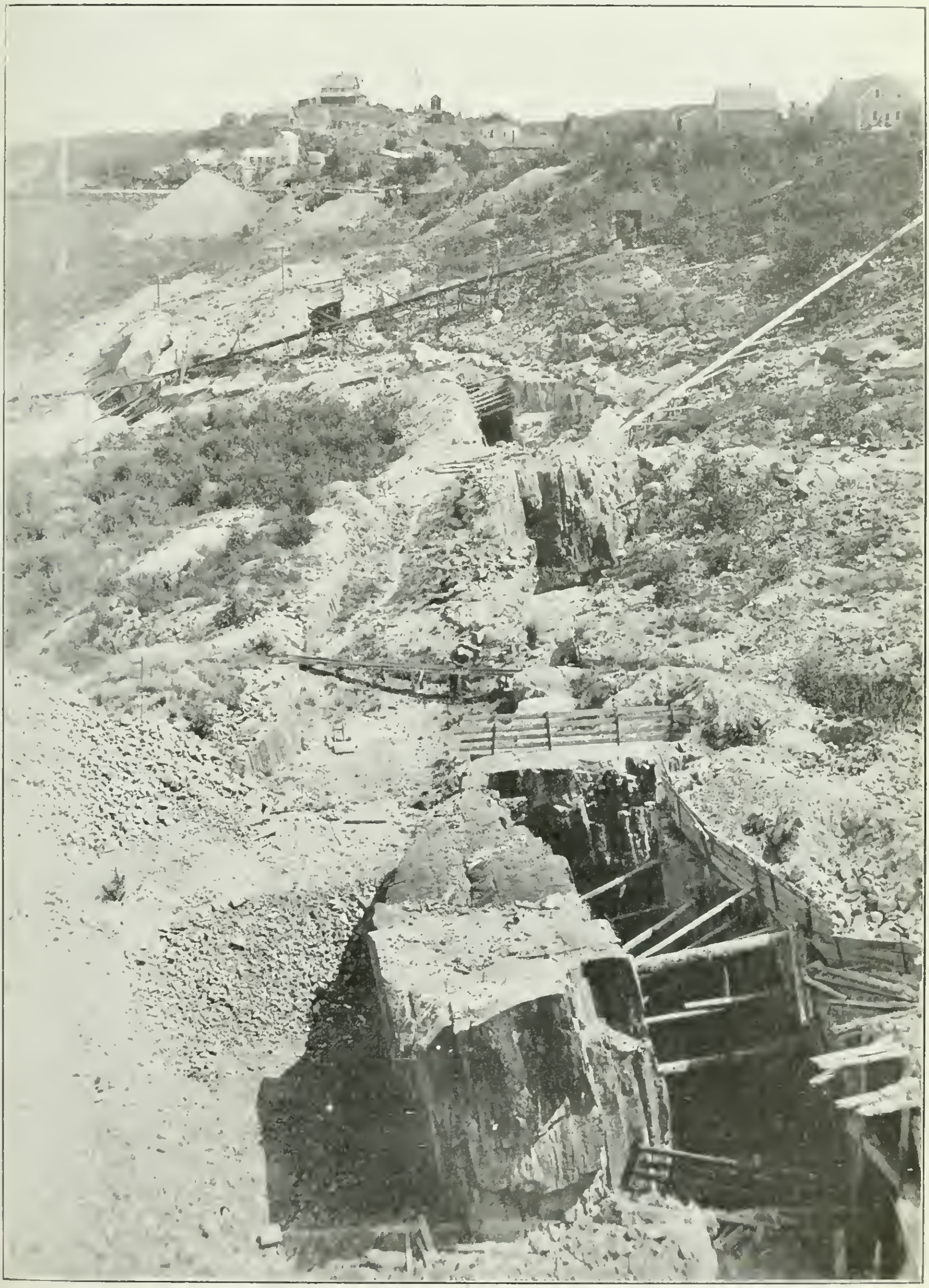


Fig. 21—Showing stopes in veins in bed of Kerr lake.

The cost of producing silver for the year ending August 31st, 1920, was 56.04 cents per ounce, including mining, developing, shipments, treatment, administration and general expenses; for the year ending August 31st, 1919, the cost was 40.81 cents an ounce, and for the previous year it was 24.74 cents.[1]

The total development work, including drifts, crosscuts, raises, winzes, and shafts, amounts to 12.2 miles.

The vein-system on the Kerr Lake and Crown Reserve is a continuous one, the boundary lines of the claims being accidental. Some of the veins on the Kerr Lake extend into the Crown Reserve, notably the Big Chamber, which is known as the Carson on the Crown Reserve; No. 10 which is known as the Ross on the Crown Reserve; and the Fleming which is known by the same name on the Crown Reserve.

The principal veins on the property are No. 10, No. 3, Fleming, No. 7, Big Chamber, Main East, and McDonald. A separate record of the production of each vein was not kept until the fiscal year ending August 31st, 1911; consequently the figures in the following table are not complete, but nevertheless serve a useful purpose. No. 3 vein at the southeast corner of the mine was one of the most important veins on the property and one of the first discovered. By August 31st, 1910, it was almost mined out, so that the production figures given in the following table have been estimated. The company has informed the writer that No. 3 vein produced between two and three million ounces of silver.

PRODUCTION OF INDIVIDUAL VEINS, KERR LAKE MINE, AUGUST 31ST, 1910, TO AUGUST 31ST, 1921[2]

Name of Vein	No. of Ounces Produced
No. 10	3,345,233
No. 3	3,000,000[3]
Fleming	2,217,512
No. 7	2,029,518
Big Chamber	1,488,401
Main East	932,352
McDonald	867,401
No. 3 Lake	557,584
No. 15	463,740
No. 8	279,290
Xmas	207,146
No. 3 Lake North	114,501
Little No. 3	89,757
No. 2	82,660
No. 218 Side	42,712
No. 21	34,542
No. 218	22,847
Little No. 7	29,796
South No. 10	22,243
No. 2 Lake	16,657
Cross	11,405
Keewatin	9,087
No. 21 Side	5,602
No. 7 Side	5,301
Split vein	3,140
No. 3A	3,000
No. 18	2,410
Little McDonald	2,393
No. 23	1,603
Crusher	1,560
No. 17	1,526
No. 2	1,315
No. 6	930
No. 19	152
No. 20	150
No. 16	100

---

[1] Annual Report, Kerr Lake Mines, Limited.

[2] Annual Reports, Kerr Lake Mines, 1911–1921.

[3] Estimated at two to three million ounces.

No. 3 vein at the southeast corner of the property is one of the most interesting in the camp. The vein occurs in the Nipissing diabase and passes down into the Keewatin, in which formation it has been explored by workings for 150 feet below the diabase. The vein proved productive, however, only in the Nipissing diabase. Even in the diabase the ore-shoot did not extend to the bottom of the sill, but came to within about 125 feet of the bottom. The stope-section, showing the ore-shoot and its relation to the diabase and Keewatin, is printed on Sheet No. 31a-3, on which are published the plans of the Kerr Lake and Hargrave mines. Assuming that the diabase has a thickness of about 1,000 feet, it will be seen from the stope-section that the ore-shoot extends upwards into the middle of the sill. It may have continued to the top of the sill, but this part has been, of course, long since eroded. At any rate this is the only instance in the Cobalt camp proper in which an important ore-shoot occurs in the centre of the diabase-sill. On the 550-ft. level, No. 3 vein in the Keewatin contained some gold at one point; assays of $1 to $18 were obtained.[1]

The No. 3 vein was very rich on the surface; the vein above the adit level up to the surface produced 170 tons averaging $1,500 per ton.[2]

Here and there along the walls of No. 3 vein there are striations dipping gently to the south, proving that some more or less horizontal movement took place along the fracture in which No. 3 vein occurs.

At the south end of the Kerr Lake property, the No. 3 vein splits into two branches and these branches continue south into the Hargrave.

Vein No. 7 had an ore-shoot about 700 feet long.[3] An idea of the richness of the ore in this vein may be obtained when it is considered that on the 140-ft. level a drift 60 feet long in the No. 7 vein produced 94,000 ounces of silver.

The Big Chamber vein has a length of about 175 feet on the 140-ft. level. It extends into the Crown Reserve where the vein is known as the Carson, the length of which was about 275 feet. The total length of the vein on the Carson and Kerr Lake is about 450 feet. The Big Chamber produced at least 1,488,401 ounces of silver, the records of production of this vein not being complete. On the Crown Reserve the vein produced over nine million ounces which was nearly half the production of the entire Crown Reserve mine.

The plans show that at the west part of the Kerr Lake mine there is a trough in the Keewatin. The axis of the trough pitches and strikes to the north. This trough or depression is best shown on the 140-ft. level. If the plan of this level be joined to the plan of the 100-ft. level of the Crown Reserve the outline of the trough will be brought out better. This trough appears to have been formed by erosion and later filled in with the Cobalt series. It does not seem to have been formed by folding after the Cobalt series was laid down, because the lower bed of slate-like greywacké, shown on the 140-ft. level of Kerr Lake and the 100-ft. level of Crown Reserve, does not conform with this deep trough. If the reader will examine these plans he will more readily grasp what is meant.

The veins in the Crown Reserve and Kerr Lake not only cross the trough, but run down the axis of the trough. Indeed, the veins have a variable strike. It would appear to the writer that the main factor governing the fractures in these two properties is their occurrence below the Nipissing diabase dome, shown in the vertical section facing page 34.

Difficulty was experienced in deciding as to where the contacts between the Keewatin and Cobalt series should be located. Where the Cobalt series rests on Keewatin basalt the contact was transitional, and therefore difficult to place. On the other hand, where the Cobalt series rests on Keewatin cherty "iron formation", at the northeast corner of the property, the contact was sharp, and more easily placed. The company's plans showed some of the contacts, which were worked out by Mr. G. R. Whitman; these plans were of assistance.

---

[1] Annual Report, Kerr Lake Mines, Limited, for year ending August 31st, 1921.

[2] Report to Directors of Kerr Lake Mining Company by W. J. Barrett, November, 1906.

[3] Annual Report, Kerr Lake Mining Company, year ending August 31st, 1909, p. 2.

The company obtained most of the silver from veins under Kerr Lake, with the exception of the silver which No. 3 vein at the southeast corner of the property produced. The plan of the adit level shows the strip of land under Kerr Lake.

A description of how and when the water was pumped out of Kerr lake is given elsewhere in this report.

The mine has been operated from No. 7 shaft at the northwest part of the claim, and from No. 3 shaft at the southwest corner; No. 3 shaft was used mainly in mining No. 3 vein.

Kerr Lake Mine Workings from No. 7 Shaft

The mine workings from No. 7 shaft are described below. Most of the ore came from veins operated from this shaft.

325-ft. Level from No. 7 Shaft.—This level was run in Keewatin and was not accessible. It is reached by a winze from the 275-ft. level, and has little work done on it. The level was run on the Fleming vein where a short shoot of fair ore was met with. The rest of the vein is barren.

275-ft. Level from No. 7 Shaft.—The east part of the level was not accessible; it is reached by a winze from the 225-ft. level, and has little work done on it. The rock is Keewatin and the drift followed the Fleming vein, which showed ore of fair milling grade with occasional spots of high-grade for over 200 feet.

The west part of the level was examined and found to consist entirely of Keewatin, together with a narrow bed of banded Keewatin "iron formation" striking southwesterly.

225-ft. Level from No. 7 Shaft.—The Big Chamber vein, the eastward extension of the Carson vein on the Crown Reserve, is entirely in Keewatin on this level. The Fleming vein is partly in Keewatin and partly in Cobalt series; that part in the Keewatin produced some high-grade ore.

The bed of Keewatin "iron formation" found on the 275-ft. level also occurs on the 225-ft. level. It is highly impregnated with zinc blende and iron pyrites. The Cobalt series forms a belt from a few feet up to 135 feet in width at the north boundary of the property.

165-ft., 175-ft., 190-ft. Levels from No. 7 Shaft.—These levels may, for descriptive purposes, be treated together. The Fleming vein has been followed for over 600 feet, and it may still be seen in the back of the stope in places where it is as wide as 15 inches. The vein dips at 67° to the south. Near the east end of the vein there is a fault dipping 60° to 79° eastward which apparently cuts off the silver content of the Fleming vein. The fault contains iron pyrites, calcite, and quartz, and is rusty. In places the iron pyrites in the fault is banded, as many as 40 bands having been counted. The character of the fault varies from point to point. Where it meets the Fleming vein it consists of two inches of calcite, four inches of iron pyrites, banded, and half an inch of gouge. In other places the fault has only a little calcite together with gouge and fault breccia. The age relation between the vein and fault was not determined.

At the northeast corner of the level the Keewatin consists of black, carbonaceous chert. At the west part there is a trough in the Keewatin floor, now filled with Cobalt series. This trough is more pronounced in the level above.

140-ft. Level from No. 7 Shaft.—This is the most comprehensive level in the mine, giving as it does a good idea of the complexity of the vein-system. The level is about the same elevation as the 100-ft. of the Crown Reserve, the levels being connected along the Carson vein. The barren parts of the Fleming vein have a width of 12 to 15 inches.

The trough in the Keewatin at the west end of the mine is well defined on this level. No. 7 vein follows along the east side of the trough and then turns westward and crosses the trough.

At the east end of the level the Keewatin consists of chert; where the bedding of the chert may be seen, it is about vertical. The chert is impregnated with iron pyrites, zinc blende, and galena, and is also carbonaceous.

A fault occurs at the northwest corner of the level. It dips 32° northward and has a reverse displacement of at least five feet.

90-ft. Level from No. 7 Shaft.—Most of the level is Cobalt series. At the south end some work has been done in the Nipissing diabase which shows that the contact of the diabase and adjacent rocks is an unusually irregular one. What is known as the "office" vein, consisting of smaltite and calcite, was not productive of silver. No. 7 vein consists of several parallel veins which join together into one or branch again into several veins.

Kerr Lake Mine Workings from No. 3 Shaft

Vein No. 3 is worked from this shaft; it was one of the most important veins in the property. The ore-shoot was wholly in the Nipissing diabase, but the lower levels were used to explore and prospect the vein in the Keewatin below the diabase. The seventh, eighth, and ninth levels are worked by a winze from the sixth level.

Ninth Level, 550 Feet below Collar of No. 3 Shaft.—This level was examined on June 6th, 1921. At that time the drift on No. 3 vein was about 60 feet in length. North of the winze the vein averaged about four inches in width. South of the winze the vein became smaller and on the face was half an inch wide. A little galena occurs in the vein. The vein assayed at one place 54 ounces of silver, but the average grade on the level was too low to pay. In the winze the vein was four or five inches in width, consisting of calcite. The rock on the ninth level consists of Keewatin cut by an 18-inch lamprophyre dike. The dike is north of the winze and dips 10° to 20° southeast.

Eighth Level, 420 Feet below Collar of No. 3 Shaft.—No. 3 vein on the eighth level pinches and swells, and varies in width from one to five inches. It consists mostly of calcite, together with a little smaltite in spots. On the north face of the drift there were three veins in the face, one of which was two inches wide while the others were narrower. The vein was barren of commercial ore.

Seventh Level, 370 Feet below Collar of No. 3 Shaft.—No. 3 vein between the winze and the north face of the drift is a strong vein averaging three or four inches and up to eight inches in width. A little native silver was found, but no ore of commercial importance was met with. The contact of the diabase and Keewatin is at the north end of the drift. The contact dips between 80° to 90° to the north. The Keewatin at the contact is chert. The No. 3 vein splits and almost pinches out on descending into the chert, although six feet from the contact it is five or six inches wide in the diabase. At the south end the drift goes into the Hargrave.

Sixth Level, 320 Feet below Collar of No. 3 Shaft.—On this level considerable crosscutting was done to explore the ground. About half a dozen veins were encountered and drifted on, but were of little value. This was the lowest level on which No. 3 vein was productive.

Fifth Level, 272 Feet below Collar of No. 3 Shaft.—The level is all run on No. 3 vein, except at the north end where an exploratory crosscut extended north into the Keewatin. On the walls of No. 3 vein, there are scratches and striations dipping gently southward, showing that some horizontal movement has taken place along the walls of the fracture in which the vein occurs.

Fourth Level, 224 Feet below Collar of No. 3 Shaft.—The level is all diabase except at the northwest corner where a drift follows a vein containing smaltite and iron pyrites.

Third Level, 179 Feet below Collar of No. 3 Shaft.—This level consists of a short drift along No. 3 vein, all in Nipissing diabase.

Second Level, 123 Feet below Collar of No. 3 Shaft.—This is an extensive level which is connected with No. 7 workings by a raise from the northwest corner. On the walls of No. 3 vein there are scratches and striations dipping 10° to 20° south.

First Level, 67 Feet below Collar of No. 3 Shaft.—This is a small level consisting of a short drift on No. 3 vein.

HARGRAVE (KERR LAKE)

The Hargrave was bought by the Kerr Lake Mines, Limited, for $16,500 during the company's fiscal year ending August 31st, 1921. After the Kerr Lake Mines acquired the property, the mine produced 35,973 ounces of silver.

According to the records of the Ontario Department of Mines, the Hargrave property produced 506,972 ounces of silver.

During the time that the property was being worked by the Kerr Lake Mines, the writer had an opportunity of examining some of the workings contiguous to the Kerr Lake property on the south. These workings are on the southward extension of the No. 3 vein and its branch.

No. 3 vein on the Kerr Lake produced between two and three million ounces of silver, but unfortunately the ore-shoot scarcely extended into the Hargrave, although the two branch veins of calcite did extend to the south as far as the Hargrave workings had been driven. The stope-section of No. 3 vein is shown on the Kerr Lake-Hargrave Sheet, No. 31a-3. It will be seen from this section that a very small part of the ore-shoot at the top and at the bottom extended into the Hargrave.

The cause of the cutting off of the ore-shoot to the south is not certainly known, but a fault, which was best seen on the 375-ft. level of the Hargrave, may have been a factor in the matter. Very little ore is reported to have occurred to the south of the fault.

The seventh level of the Kerr Lake mine was extended south into the Hargrave workings, as shown on the plan of the sixth and seventh levels of the Kerr Lake mine. No. 3 vein splits, and branches were drifted on for about 100 feet. This level had not been directly connected with the Hargrave shaft No. 3. The rock is all Nipissing diabase, which is considerably disturbed in places, the numerous joint planes in the rock being polished and striated. A small shoot of ore was found in the east branch of No. 3 vein above the level, yielding 35,973 ounces of silver.

The 375-ft. level of the Hargrave is an extensive one. The writer examined that part of it south of the Kerr Lake. On this level there is a fault striking a little east of south and dipping almost vertically. The fault cuts across No. 3 vein about 20 feet south of the boundary line. The east branch of No. 3 vein gradually converges toward this fault, and enters the fault at a very gentle angle. On the seventh level this fault was not a clear-cut fracture, but appeared to be represented by the crushed and striated diabase referred to in the preceding paragraph.

The writer did not have an opportunity of examining the fault on the higher levels of the Hargrave mine. It would have been of interest to see what relation the fault had to the ore-shoot on No. 3 vein in the upper part of the mine.

The Hargrave workings east of the Kerr Lake claim were not examined.

LA ROSE MINES

La Rose Mines, Limited, has a capital of $1,500,000 in shares of a par value of $1.00; all the stock has been issued. The company has produced 25,897,914 ounces of silver, and has paid $7,655,410 in dividends to the end of the year 1922.

The company owns La Rose mine, La Rose Extension, the Violet, the Princess, the Lawson, the University, and the Fisher-Eplett. Most of the production has come from La Rose.

The writer is indebted to Mr. G. C. Bateman, manager of La Rose mine, for the figures giving the shipments from La Rose, Lawson, University, Princess, and Violet.

La Rose

La Rose mine was not working during the time of examination and, moreover, the workings, with the exception of the tunnel levels, were flooded. The plans of the mine in the pocket at the back of the report show the geology of the tunnel levels. This geological mapping was done by Mr. James Hill.

It was a source of regret to the writer that he was not able to examine this historic mine. The main vein was one of the first found at Cobalt, the McKinley-Darragh being the first for which an application was sent to the Government. The main La Rose vein was the first one in the camp to have a blast put in it.[1]

La Rose mine produced 17,479,977 ounces of silver to the end of the year 1922.

The report of the company to the shareholders dated June 20th 1908, contains three reports from three different sources on the operations of the company up to that time. These and later annual reports of the company give excellent descriptions of the property. The main vein was the most important one. On the 62-ft. level this vein had an ore-shoot about 850 feet long, which averaged about 700 to 1,000 ounces to the ton from ore taken from the drift in this level. It was richer in other places, assays from 3,000 to 14,000 ounces having been obtained. The vein really consisted in places of two to four roughly parallel veins and the average width of ore was 8 to 12 inches. The vein has, according to the descriptions in the annual reports, been faulted here and there by minor faults.

Cobalt Lake Fault

The Cobalt lake fault is a reverse one with a displacement of approximately 275 feet. At the McKinley-Darragh the displacement is greater. It has been prospected down to the 665-ft. level, as indicated on the vertical section facing page 8. No ore of commercial grade was found in it, although a large calcite vein was discovered in places. On the 380-ft. level the fault was drifted on for 500 feet; a strong vein of calcite, in places three feet wide, lies along the fault. It carries silver throughout, but no high-grade ore has been developed. On the 500-ft. level the fault was followed for 130 feet and a large calcite vein was found which carried only a small quantity of silver. An inclined shaft was sunk on the fault for a distance of 233 feet below the 500-ft. level. Near the bottom, at a depth of 215 feet, drifts were run both ways for a combined length of 80 feet. No ore of commercial importance was found.[1]

---

[1] W. G. Miller in the Report of La Rose Consolidated Mines Company, June 20th, 1908.

Relation of Cobalt Lake Fault to Main La Rose Vein

The writer has not had an opportunity of investigating the age relation between the main La Rose vein and the Cobalt lake fault; nor are there any published descriptions concerning this question. It was learned, however, from those in charge of operations, that the vein extended into the fault at the north and south ends. The vertical section facing page 8 shows the vein extending down vertically into the fault. It would appear therefore that the vein is really a branch fracture of the Cobalt lake fault and that this branch fracture rises up vertically from the fault. Certain it is that the main La Rose vein has not been found on the west side of the fault, although it has been diligently searched for in La Rose, La Rose Extension, Chambers-Ferland, and Right of Way mines.

McDonald and No. 3 Veins

There are several other veins on the La Rose, chief of which are the McDonald and No. 3 veins. These strike eastward and southeastward, or about at right angles to the main vein. The McDonald extends into the O'Brien, thence eastward across the O'Brien and possibly into the Violet mine. The combined length of the McDonald vein on the three properties is about two-thirds of a mile, probably the longest vein-system in Cobalt; the ore-shoots are not continuous for the whole length. On the O'Brien the vein is known as No. 1. It should be added here that No. 1 vein on the O'Brien had not been connected up by mining operations with the Violet veins, and therefore it cannot be definitely said that No. 1 vein on the O'Brien extends into the Violet.

The McDonald vein has a stope at least 445 feet long,[2] while on the O'Brien the stope is 900 feet long, making a continuous ore-shoot at least 1,345 feet long.

No. 3 vein persisted from the Cobalt series into the Keewatin, and contained high-grade into the Keewatin at least to the 135-ft. level of No. 3 shaft. On the 236-ft. level the vein was small and low-grade.

Fault 64

The fault known as "No. 64" has been followed in a tunnel at the northeast corner of the claim. The fault is a normal one with a displacement of about four or five feet, the south side being the downthrow side. There is a fault breccia a foot wide in places, and the fault is about vertical. A vein occurs in this fault for a distance, after which it leaves the fault and turns southwestward into the Chambers-Ferland. The fault lines up with the O'Brien and Violet faults (Fig. 8). It is supposed also that it extends westward into the Chambers-Ferland, Nipissing, and Hudson Bay; but as the fault has not been followed by mine workings through the Cobalt lake fault, it is not known definitely that it is continuous across all the above properties.

---

[1] Sixth and Seventh Annual Reports, La Rose Consolidated Mines Company, for years 1913 and 1914.

[2] Third Annual Report, La Rose Consolidated Mines Company, for year ending May 31st, 1910, p. 10.

La Rose Extension (La Rose)

La Rose Extension has not produced any silver, although considerable work has been done on it. The writer examined what is called the 380-ft. level on May 3rd, 1923. This level is 340 feet below the collar of No. 10 shaft and is reached from the shaft. The level is all in Cobalt series. A major fault was met with in three crosscuts north of the shaft. The fault dips at 58° to 62° southeastward; its location is shown on the plan of this level. In the first crosscut north of the shaft, the rocks are crushed for about 100 feet in the vicinity of the shaft.

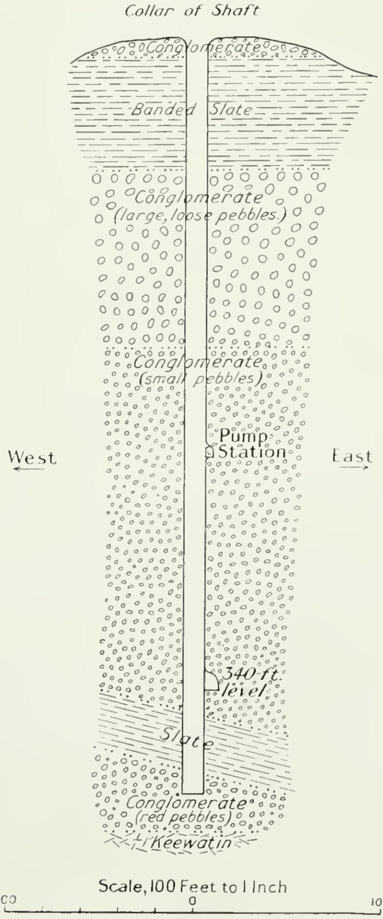

Collar of Shaft
Conglomerate
Banded Slate
Conglomerate (large, loose pebbles.)
Conglomerate (small pebbles)
Pump Station
West
East
340 ft. level
Slate
Conglomerate (red pebbles)
Keewatin
Scale, 100 Feet to 1 Inch
100
0
100

Fig. 22—Vertical section through No. 10 shaft on northwest part of J.B. 4, La Rose Extension, furnished by La Rose Company. The shaft was not geologically examined by the Ontario Department of Mines. The rocks in the shaft are reported to belong to the Cobalt series.

Violet (La Rose)

The Violet is east of and contiguous to the O'Brien. It has produced 404,204 ounces of silver to the end of the year 1922. On the surface on the west part of the property there were no veins exposed, but, as the O'Brien was mining ore bodies near the Violet boundary, La Rose management decided to sink a shaft and explore the ground east of the O'Brien. This shaft was sunk to a depth of over 410 feet and levels established at 330 and 410 feet, with two sub-levels at 250 and 315 feet. At the 410-ft. level, a winze was sunk over 600 feet below the collar of the shaft and levels established at 470, 530, and 600 feet.

A lawsuit having determined that this shaft was on the O'Brien property, La Rose management decided to sink another shaft, which on our plans is named the "new shaft." The new shaft was finished to the 600-ft. level by the spring of 1923, and connected with the 600-ft. level of the winze from the old shaft.

The work from the two shafts proved the existence of two main veins. No. 5 vein strikes eastward. No. 3 vein strikes southeastward and dips about 65° to the southwest.

There is a bed of Keewatin "iron formation" striking a little west of north on the 330-ft. level. This bed was also encountered in the O'Brien and at points farther westward. The "iron formation" dips steeply to the south.

The Violet fault probably follows the strike and dip of the "iron formation." In fact this fault, which extends westward to the O'Brien, La Rose, Chambers-Ferland, Nipissing, and Hudson Bay, appears to follow the bed of "iron formation" across these properties. Neither the fault nor the "iron formation" has, however, been traced continuously across these properties. The fault dips at 80° to 90° to the south and has a fault breccia 2 to 14 inches wide.

600-ft. Level.—This level was not accessible at the time of examination, but No. 3 vein is reported to have been met with and high-grade ore and mill-rock encountered in the drift.

530-ft. Level.—No. 3 vein appears to follow a narrow lamprophyre dike. There is much pyrite in the Keewatin near the shaft.

470-ft. Level.—The No. 3 vein has been drifted on for over 500 feet and it may be seen to pass from the Keewatin to the diabase. The isolated area of Keewatin on this level appears to be a great included block of Keewatin basalt caught up in the Nipissing diabase. The new shaft penetrated and passed through this block of Keewatin, as shown in the coloured section facing page 8.

330-ft. Level.—The structure in parts of this level was rather difficult to work out. The crosscut running north of the shaft followed about the base of the Cobalt series, and the contact between the Keewatin and the Cobalt series was transitional; the contact was consequently difficult to locate. About 20 feet north of the shaft the conglomerate and greywacké of the Cobalt series were met with, and these rocks were followed in the crosscut for about 135 feet, at which point fine-grained cherty beds of silicious sediments belonging to the Keewatin "iron formation" were encountered and followed to the north for 160 feet in the crosscut. The cherty sediments are in most places finely bedded; they strike eastward, and dip to the south at steep angles, 70° to 80°.

About 165 feet north of the shaft a vein, No. 5, was met with, striking east and west. This vein was followed for about 420 feet. It is, in places, a strong-looking vein one to five or six inches wide, although towards the east it averages in places less than a quarter of an inch. It consists mainly of calcite, but a short distance east of the crosscut the vein consists of two or three inches of smaltite. It has been stoped at the west end.

The rocks along the drift following No. 5 vein consists largely of fine-grained cherty beds of the Keewatin "iron formation," which are cut by dykes of lamprophyre.

The conglomerate and greywacké in the crosscut, and in the drift on No. 5 vein, have a brownish colour, which gives the rock an uncommon appearance.

The Violet fault was met with about 90 feet north of the shaft.

315-ft. Level.—This is a small sub-level on vein No. 5 above the west end of the 330-ft. level. The Violet fault was also encountered in this level.

250-ft. Level.—This is a sub-level which is reached by a raise from the 330-ft. level; the raise follows No. 5 vein. The contact between the Keewatin series and the Cobalt series is about 30 feet above the 330-ft. level in this raise.

The 250-ft. level in a general way follows the contact between the Nipissing diabase and the conglomerate and greywacké of the Cobalt series. The dip of the contact of the diabase is steep between the 250-ft. and 330-ft. levels.

On this level the Violet fault has been followed for about 100 feet. As nearly as may be determined, the fault strikes southeastward and dips at about 80° to the southwest. It consists of two to 14 inches of gouge and fault breccia and in places contains galena. Here and there it carries as much as 10 per cent. of galena, the remaining part of the fault consisting of gouge and crushed rock. The only level on which the fault intersects the No. 5 vein is the 250-ft. At the west end the vein continues up to the fault, but does not apparently occur on the southwest side of it. About 65 feet westward down the vein, a vein occurs on the southwest side of the fault, but whether this is the faulted part of No. 5 vein, or another vein, could not be determined at the time of the examination, the back of the drift being about 20 or 25 feet above the floor.

90-ft. Level.—This level is reached from a shaft at the south part of the claim. It was not accessible at the time of examination.

Princess (La Rose)

The Princess mine is west of and contiguous to the McKinley-Darragh. The property has produced 3,713,806 ounces of silver to the end of the year 1922.

Scarcely any of the veins came to the surface; they pinch out to mere cracks before they rise to that height.

The mine has been worked from four levels, namely, the first, second, third, and fourth; these levels are respectively 45, 132, 185, and 230 feet below the collar of the shaft.

A very interesting structure occurs on the lower levels. There is a vein on these lower levels which is limited as to depth by the Keewatin below, and as to height by the contact fault. The fault is about 12 feet above the contact, so that the vein is only 12 feet high; it pitches down along the Keewatin floor as far as the workings had extended on August 2nd, 1921. Up to the date mentioned, the vein was said to have produced $50,000 in silver. This vein is another of the numerous examples which show how the ore follows the Keewatin contact. In this case the ore rises an exceptionally short distance above the Keewatin.

The levels, beginning with the lowest, are described below:—

Fourth Level.—This level had about 500 feet of crosscuts and drifts up to August, 1921. The main crosscut follows in a general way the contact between the Keewatin and Cobalt series. A fault just above the contact is well exposed by the workings. It occurs from a few feet to about 12 or 15 feet above the Keewatin floor. This fault is of economic importance on this level because it completely cuts off vein No. 405; that is to say, the vein has not been found above the fault, and the ore is cut off in the Keewatin below. Above the fault there occurs a thick bed of quartzite.

In the vicinity of this vein the succession of the sediments of the Cobalt series is as follows: On the Keewatin rests a bed of conglomerate about 12 or 15 feet thick; this is followed by a somewhat ill-defined bed of slate-like greywacké, a foot or two wide; above the slate is a thick bed of quartzite. The contact fault follows the bed of slate-like greywacké.

From the fourth level an inclined winze along the Keewatin floor was being sunk on the vein in August, 1921, and on the second day of that month the winze was down about 30 feet. On the face at the bottom of the winze, the vein was a strong one, two to eight inches wide, consisting of calcite, smaltite, and some native silver.

The vein appears to be younger than the fault, as it does not show any drag, nor is it disturbed by the fault. The fracture in which the vein occurs does not extend upward through the fault into the thick bed of quartzite above the fault. Perhaps the thick, massive bed of quartzite was too unyielding to allow the fracture to extend into it; or perhaps the fault was the controlling factor which prevented the fracture from extending upwards into the quartzite. A search for the vein above the fault failed to locate it.

Third Level.—An interesting feature of this level is the development work which has been performed on the Cobalt lake fault, the only level in the mine in which the Cobalt lake fault has been encountered up to the time of our examination. The fault has been drifted on for over 200 feet. At the northeast end of the fault masses of pure smaltite occur in the fault. One of these is 18 inches in length by about 8 inches wide. It is roundish in shape and striated and polished. There are scores of these masses of smaltite in the fault. The curious thing about them is that they are all roundish, polished, striated, and slickensided, as though they had been disturbed by a late movement which took place in the fault after the smaltite was deposited. The length of that part of the fault containing the smaltite masses is 25 or 30 feet. This is the only spot in the Cobalt lake fault in which the vein has been disturbed by movements in the fault after the ore was deposited. Cobalt bloom is profusely developed in this part of the fault. Beyond this, to the southwest, cobalt bloom occurs here and there along the gouge of the fault. The company sampled the entire length of the drift in which the fault occurs and found that the rock averaged about three ounces of silver per ton.

The contact fault is well developed in this level.

In some of the Keewatin workings, in line with vein No. 405, there is a fault consisting of gouge and crushed rock an inch or two wide dipping steeply to the southwest. In it here and there is a vein of calcite and a little quartz, less than an inch wide. This fault vein may be the downward extension of vein No. 405 into the Keewatin.

Sub-level.—What is known as the sub-level, or intermediate level, is about 20 feet below the second level. There is a network of veins on this level, and some stopes of considerable size, 10 to 20 feet or more wide. The workings on this sub-level are most irregular.

Second Level.—Much of the second level is inaccessible; the southwest part, for instance, having quite extensive crosscuts which are now dammed off by concrete dams. We were not able to examine these workings; the information regarding the location of the contacts between the Keewatin and Cobalt series was kindly furnished by the company. Where we could see the contact of the

Keewatin and Cobalt series it was found to be irregular; that is to say, the Keewatin floor was weathered into valleys and hills, which were filled with conglomerate.

The contact fault was found at two places dipping 25° southeastward; other places where it should normally be found were inaccessible.

The main veins on the property are found on this level, and have stopes on them 15 or 25 feet wide in places.

First Level.—The first level is not important, there being only a small amount of work accomplished.

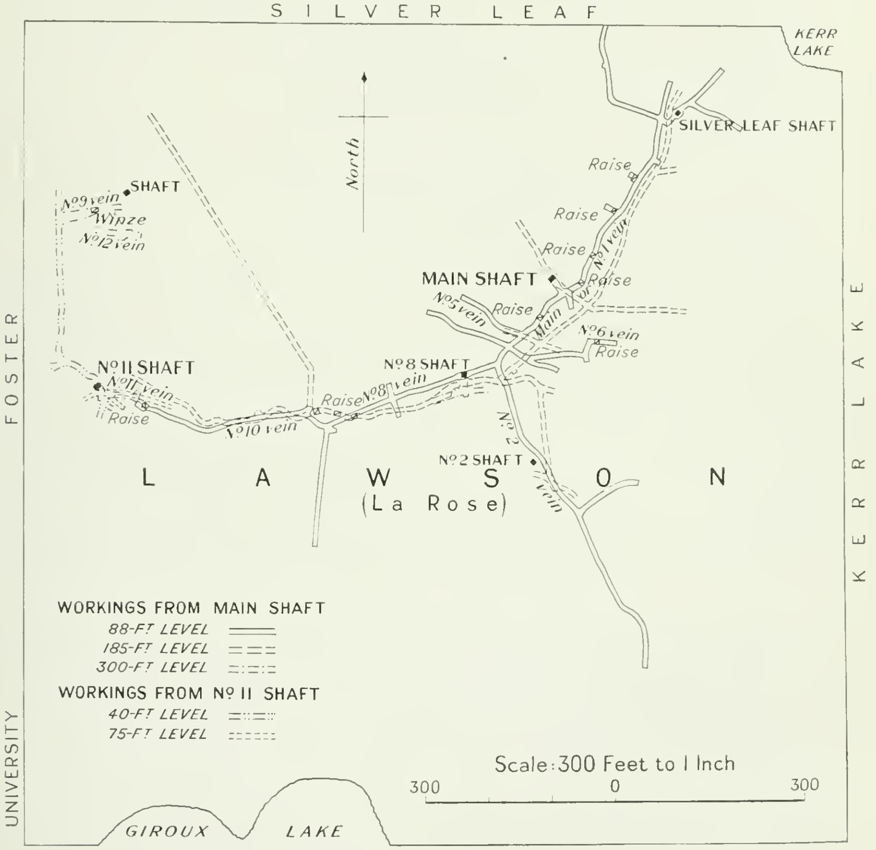


Fig. 23—Plan showing mine levels at Lawson (La Rose).

Lawson (La Rose)

The Lawson was not working at the time of our survey, and no examination was made. The plans of the levels (Fig. 23), were kindly furnished by the company. The property produced 4,213,553 ounces of silver to the end of the year 1919. Some of the veins yielded exceedingly rich ore.

The following summary of the work at this property was obtained from the annual reports of La Rose.

The development of the main vein, No. 1, proved disappointing; the ore body which promised so much at the outcrop held its value only to a shallow depth.[1] Veins Nos. 2, 5, and 8, 9, and 11 developed good ore-shoots. No. 2 vein is in Keewatin and had an ore-shoot on the 88-ft. level 140 feet long. A stope on No. 5 vein was 130 feet long in the year 1910. On vein No. 8 at the 188-ft. level an ore-shoot of very high-grade ore, 80 feet long, was opened up. No. 9 vein on the first level had a shoot 70 feet long, about four inches wide, assaying 2,000 to 3,000 ounces of silver per ton.

In the year 1911, the mine produced 1,321,000 ounces of silver. A small shoot of ore assayed 9,656 ounces of silver per ton. The ore in this vein occurs in small, rich pockets.

No. 5 vein and the main vein proved barren on the 400-ft. level.

At the end of the year 1915, all the known ore had been mined. The mine was closed in 1917, but ore from the surface dumps was still being shipped.

University (La Rose)

The University property produced 879,599 ounces of silver to the end of the year 1922. At the time of examination in 1920 and 1921, the old workings at the east end of the claim, adjacent to the Lawson, were not being operated. The workings at the west part, from the shaft near the shore of Giroux lake, were, however, being operated.

The structure of the rocks at the University mine is illustrated in the vertical section facing page 40. This section, which is drawn through the University shaft at the west part of the property, extends northward through the Penn-Canadian shaft. At the University shaft, the Nipissing diabase forms an arch; north of the shaft the diabase dips at some 45° to the north, while south of the shaft it dips to the south at about the same angle. The structure has the appearance of an anticline, but it is evident that this anticline-like structure has not been caused by folding. Had folding caused the formation of the arch, the Cobalt series below the arch would also have been folded into an anticline. This is not the case, as is shown by the vertical section. Indeed, the Cobalt series below the arch has been folded the opposite way into a gentle syncline or basin.

The writer believes that the Nipissing diabase sill was intruded from the southeast towards the northwest in the form of an arch, and that, in the vicinity of the University shaft, it first ripped upwards across the bedding of the sediments of the Cobalt series, then turned downwards at a right angle forming an arch. It then very soon flattened out, and, when it reached the Bailey and Penn-Canadian, it selected a single bed in the slate-like greywacké and followed this bed for some distance.

The Cobalt series around the University shaft is not thick; in the section referred to is it about 135 feet. There is a basal conglomerate about 50 feet thick, followed by a bed of slate-like greywacké 70 feet thick, and at the top a bed of quartzite about 15 feet thick. These dimensions are approximate.

The bed of slate-like greywacké is the productive formation. Although the veins extend down into the conglomerate, no silver of importance has been found in the conglomerate.

The vein-system is a short one striking northeastward. There are five comparatively small levels at 60, 90, 110, 120, and 145 feet below the collar of the shaft.

On the 145-ft. level, an exploratory crosscut was run northward. It passed first through Keewatin basalt and then encountered conglomerate of the Cobalt series which did not come down to the floor of the drift. There is a gradual transition between the Keewatin basalt and the conglomerate of the Cobalt series which made it difficult to place the contact. The diabase dips at 34° northward.

---

[1] Third Annual Report, La Rose Consolidated Mines Company, for year ending May 31st, 1910.

The 110-ft. and 120-ft. levels are very small, consisting of a drift on the vein-system. The 60-ft. level consists of a stope in the bed of slate-like greywacké.

At the east end of the University, La Rose company did some work in 1914 by running a crosscut from the Lawson mine into the University to cut No. 1 vein opened up in the old workings. The ore exposed by the old University company on this vein was sampled and found to be generally low-grade. Subsequent shipments were made, and 1,479 tons were milled and found to yield 17.42 ounces per ton. No. 2 vein, which produced some high-grade ore at the outcrop, was reached by a crosscut from the second level of the Lawson, but proved valueless at depth.[1]

Fisher-Eplett (La Rose)

The property was not accessible, and the following information is taken from the annual reports of La Rose.

The claim was first thoroughly trenched and a number of veins were discovered, one of which was a strong vein containing a short shoot of high-grade ore. A shaft was sunk, and at the 200-ft. level four veins were developed of good size, carrying considerable cobalt and nickel with the calcite, but with low silver content. On the 300-ft. level, crosscuts explored the rock for almost the full width of the property to the vicinity of the granite contact. Much drifting was also done. Numerous calcite veins were encountered, but none had any commercial ore. The property was closed and the plant removed in 1914. Much water was encountered in the mine, which made operations expensive.[2]

CROWN RESERVE

The Crown Reserve Mining Company, Limited, had, during the operation of its Cobalt property, a capitalization of $2,000,000 in shares of a par value of $1.00. Recently the capitalization has been increased as a result of its activities in acquiring certain gold properties elsewhere.

The company has produced 20,071,472 ounces of silver from its Cobalt property and has paid $6,190,849 in dividends. The company ceased active operations at its Cobalt property on January 30th, 1921, except for the hand-sorting of the dump in a small way by a few men.

The cost of producing silver is shown in the following table, which is copied from the annual report of the company for the year ending December 31st, 1919. The cost varied from 7.5 cents an ounce to 94.4 cents an ounce. In 1909 the cost per ounce was 10.31 cents which, in the opinion of the management, was lower than the production cost not only of any other mine in Cobalt, but probably of any other silver mine in the world.[3] The company did not own a mill, consequently its ores were treated in certain other plants.

---

[1] Ninth Annual Report, La Rose Consolidated Mines Company, for year 1915, p. 11.

[2] Eighth Annual Report, La Rose Consolidated Mines Company, for year 1914, p. 11.

[3] Annual Report of the Crown Reserve Mining Company, Limited, for the year ending December 31st, 1919.

AVERAGE COST OF PRODUCING SILVER TO THE END OF YEAR 1919, CROWN RESERVE

Year	Net production in ounces	Total cost	Price received per oz.	Cost per ounce	Profit per ounce
			cts.	cts.	cts.
1908	1,798,954	$135,073.56	50.64	7.50	43.13
1909	4,034,325	416,140,90	51.56	10.31	41.25
1910	3,248,196	389,700.48	54.10	11.97	42.13
1911	3,430,902	366,108.53	53.46	10.67	42.79
1912	2,714,766	380,812.96	62.32	14.02	48.30
1913	1,776,678	408,956.13	59.45	23.02	36.43
1914	1,425,320	414,552.40	51.92	28.95	22.97
1915	657,395	344,596.00	52.40	45.01	7.39
1916	274,470	190,266.61	70.40	69.30	1.10
1917	329,670	183,265.97	80.63	55.60	25.03
1918	202,505	191,255.85	97.78	94.44	3.34
1919	196,812	155,804.05	118.80	79.20	39.60
Total..	20,089,993	$3,576,533.44			

The mill and smelter returns to the end of the year 1919 are given in the following table, which is copied from the report to which reference has just been made.

MILL AND SMELTER RETURNS TO END OF 1919, CROWN RESERVE

Year	Gross ounces returns	Gross value	Value
1908	1,798,954	$910,350.62	$854,788.89
1909	4,034,325	2,080,156.08	1,895,484.92
1910	3,248,196	1,757,824.27	1,633,716.66
1911	3,430,902	1,833,516.80	1,751,300.21
1912	2,714,766	1,692,060.76	1,638,191.58
1913	1,776,678	1,056,271.86	1,040,117.98
1914	1,425,320	740,092.70	722,873.21
1915	657,395	344,596.00	339,425.81
1916	274,470	193,239.89	191,822.34
1917	329,670	265,839.02	265,155.32
1918	202,505	198,791.35	198,011.35
1919	196,812	233,810.91	233,034.32
Total..	20,089,993	$11,306,550.26	$10,763,922.59

After a successful and profitable period of production, the Crown Reserve in 1920 reached a stage where the known ore bodies were practically worked out. In the year 1919 the company hoisted and delivered to the Dominion Reduction Company's custom mill at Cobalt 13,755 tons of ore, which averaged 15 ounces of silver per ton. During the year 1920 the output was still further reduced; the year was a disappointing one, there being a deficit of $72,054.

The company has since acquired a gold property at Larder lake, with the merits of which it is not the province of this report to deal.

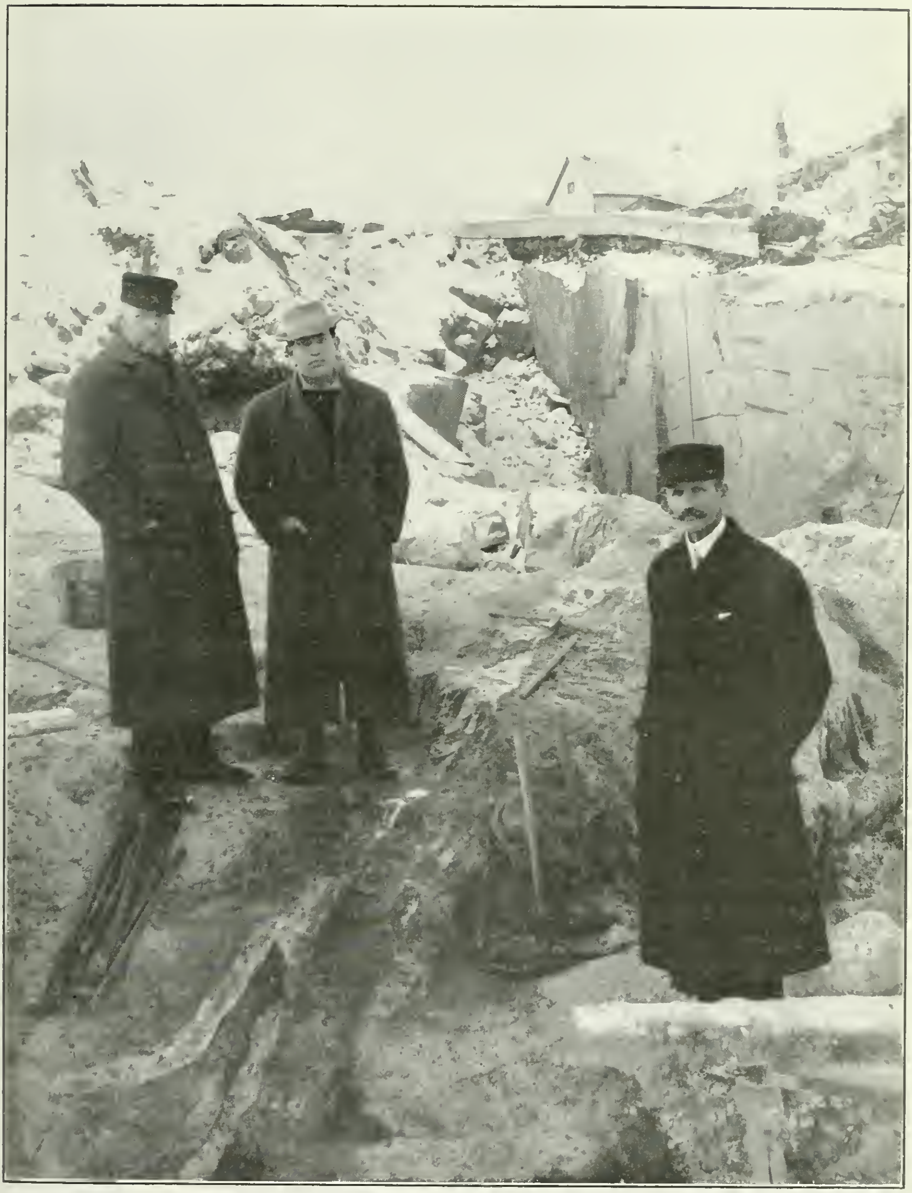


Fig. 24—Crown Reserve, Carson vein in the foreground, November, 1907. On the left, the late Sir John Carson after whom the Carson vein was named; centre, Mr. S. W. Cohen; right, Mr. J. G. Ross.

Development

The total mine development to the end of the year 1920 amounted to about eight miles, made up of sinking, raising, drifting, and crosscutting, as shown in the following table.[1]

TOTAL MINE DEVELOPMENT, CROWN RESERVE

Development	To 1919	1919	Total
	feet	feet	feet
Sinking and raising	4,062	305	4,367
Drifting	18,573	1,305	19,878
Cross-cutting	15,512	1,088	16,600
Total	38,147	2,698	40,845

Development in 1920 amounted to 2,146 lineal feet, making the total development work 42,991 lineal feet, or 8.1 miles.

Structure

The structure of the rocks, and the relationship of the veins to the rocks, is shown in the vertical section facing page 34. This section is based on a general one in Miller's report,[2] and on a more detailed one kindly furnished by the Crown Reserve Mining Company; the latter, which showed the mine workings, was signed by A. R. Whitman. Certain changes were made in Whitman's section, particularly in reference to the contact between the Keewatin and Cobalt series. The location of the quartz-gabbro, lamprophyre dikes, and chert beds has also been added.

The section is drawn in a north and south direction through the Crown Reserve shaft and the Silver Leaf shaft north of Kerr lake. It will be noted that the central and lower parts of the section consist of Keewatin basalt cut by lamprophyre dikes of Haileyburian age. On top of the Keewatin is the Cobalt series, consisting of conglomerate, greywacké, slate-like greywacké, and quartzite, having a maximum thickness of about 255 feet, the series dipping at gentle angles to the north. At the north end of the section the Nipissing diabase dips at an average angle of about 45° to the north, cutting across the bedding of the Cobalt series. At the south end of the section the diabase dips to the south at an average angle of about 45°. As explained elsewhere in this report, the Nipissing diabase sill in the Kerr lake-Giroux lake area occurs in the form of an elongated dome, the longer axis of which strikes a few degrees north of east. The top of the dome has been eroded, and at the Crown Reserve only the lower limbs remain. It is believed that the diabase was intruded in the form of a dome, and that folding did not cause the sill to take its dome-like shape. Had folding caused the sill to take this form, the sediments of the Cobalt series below the dome would also have been sharply folded. This is not the case, as the sediments dip at gentle angles.

The ore-shoots occur almost entirely in the Cobalt series. They are barren of silver in the diabase, and barren, comparatively speaking, in the underlying Keewatin, although the Carson vein, a very strong one, appears to have produced some silver in the Keewatin. The productive part of the Cobalt series forms a wedge, as shown by the vertical section. On top of this wedge is the Nipissing diabase sill, while below is the Keewatin.

---

[1] Annual Report of the Crown Reserve Mining Company, Limited, for the year ending December 31st, 1919.

[2] Annual Report, Ont. Bur. of Mines, Vol. XIX, pt. II, 1913, p. 92, section KJ.

While it is true that the Nipissing diabase has not been productive on the Crown Reserve and Silver Leaf, it should, however, be pointed out that very little work has been done on the veins in the diabase. The most work accomplished was done on vein No. 17 on the 150-ft. level, where the vein was followed into the diabase about 65 feet. It has not yet been demonstrated that the Nipissing diabase is barren in the area north of the Crown Reserve workings.

The Cobalt series has a maximum thickness of about 255 feet; the following table gives the kinds of rock and their approximate thickness, the lowest bed being shown at the base of the column.

THICKNESS OF COBALT SERIES, CROWN RESERVE

Kind of rock	Approximate maximum thickness, feet
Quartzite	35 plus
Slate-like greywacké, third bed	80
Conglomerate	15
Slate-like greywacké, second bed	15
Conglomerate	55
Slate-like greywacké, first bed	15
Conglomerate	40
Total	255

While the Cobalt series has a total thickness of about 255 feet, it may be pointed out that near the Carson vein it is not much over 100 feet. It will be noted that there are three beds of slate-like greywacké. The lowest one, the first bed, does not come up to the 250-ft. level.

Veins

There are about a dozen productive veins on the property. The company kept a record of the production of these veins, as shown in the table below. This record was published in the annual report of the company for the year ending December 31st, 1919, and was revised for the Ontario Department of Mines by H. J. Stewart.

SILVER PRODUCTION OF VEINS, CROWN RESERVE, TO END OF YEAR 1919

Vein	Production, ounces
Carson	9,211,279
Gear	2,463,500
Ross	2,757,500
Victoria	585,500
No. 10	549,000
No. 17	2,821,000
No. 23	89,000
No. 25	12,700
No. 19 (Fleming)	176,780
No. 29 (17)	988,000
North vein	100,000
Miscellaneous	62,797
	19,817,056
Dump	550,000
Total	20,367,056

From the information summarized in the above table, it may be seen that the Carson vein was the most productive on the property, its output of 9,211,279 ounces being almost equal to one-half of the entire production. This yield was obtained above the 200-ft. level. The length of the vein on the Crown Reserve property was only 286 feet, but it extended into the Kerr lake property, where it was known as the Big Chamber. On the Crown Reserve it was explored to a depth of about 500 feet, but it was not productive below the 200-ft. level. Most of this yield appears to have come from the vein where it occurs in the Cobalt series, but there must also have been some production from the vein where it occurs in the Keewatin series, since the vein is stoped between the 200-ft. and the 100-ft. levels and the rock between the 100-ft. and the 200-ft. levels is largely Keewatin. The Cobalt series has a thickness of about 100 feet at the Carson vein, but east of the shaft it is thicker. The contact, however, between the Cobalt series and Keewatin series on the 100-ft. level is a transitional one, and it is therefore only possible to show the approximate line of contact.

Mr. Samuel W. Cohen, who was general manager of the Crown Reserve mine for many years, has kindly given the writer some interesting information regarding the richness and size of the Carson vein. In 1908, when the 100-ft. level of the vein was being opened up, the company produced approximately 900,000 ounces of silver from a drift 200 feet long. In one spot in the drift the vein was 33 inches wide and the ore contained about 12,000 ounces of silver per ton. At one place in the open cut, the vein was 37 inches wide. The actual yield of the whole Carson vein in high-grade alone is over 9,100,000 ounces of silver, produced from a section 286 feet long and averaging 150 feet deep, which includes the lean as well as the rich spots. This gives an average production per square foot of vein area of 217 ounces which, Mr. Cohen believes, is the largest unit production of any silver vein that was ever known, on a section comparable in size with that stated.[1]

The vein of next importance is No. 17. It strikes about north-northeast, and has a length of about 500 feet. It has been followed into the diabase for some distance, but has not been productive in that rock. Anyone disposed to take a gamble might be inclined to prospect this vein in the Nipissing diabase.

At the time of our examination of the property in August and September, 1920, the veins were practically worked out; very little information could be obtained by peering into empty stopes and, as the annual reports of the company deal largely with financial matters, the writer was able to obtain little or no information regarding the characteristics of most of the veins. As the table of production shows, the Gear, Ross, Victoria, and No. 10 veins were large producers. The Fleming vein, however, was a disappointment. On the Kerr Lake property this vein was a large producer, but, where explored on the Crown Reserve, it produced only 176,000 ounces of silver.

At the east end of the property on the 200-ft. level a small production came from No. 23 and No. 25 veins, namely, 89,000 ounces and 12,700 ounces of silver, respectively.

The vein known as the North vein produced about 100,000 ounces of silver. This vein was productive in the Keewatin, and has the distinction of having the deepest workings in the mine, namely, 800 feet deep. The company reports that the vein contains gold, assays as high as $12.00 per ton having been obtained. No native gold was found. The vein may be best examined on the 500-ft. level where it may be seen for 450 feet in the drift. It is a fault vein striking eastward and dipping 70° to the south.

---

[1] Private communication from Samuel W. Cohen, May 4th, 1923.

Pumping of Water out of Kerr Lake

In the year 1913, the water in Kerr lake was pumped out in order to allow the mining of veins which came to the surface under the water of the lake. The operation was carried on jointly by the Crown Reserve and Kerr Lake mining companies.

Pumping was actively begun on the 28th of August, 1913, and in four weeks most of the clear water had been pumped out, lowering the lake 28 feet and leaving silt and mud. Pumping of the silt and mud was continued until November 28th, lowering the lake another 10 feet, making in all a lowering of water, silt, and mud of 38 feet. About 325,000,000 gallons of water, silt, and mud were pumped out. After the clear water was pumped out, it was found that there was an average depth of 25 feet of mud and silt, over the whole lake.

Four single-stage pumps, installed on a 100-ton barge, were used, each pump having a capacity of 1,800 gallons a minute. The pumps were arranged in two units, each unit being directly connected with a 250-horsepower motor.

In 1914 about 600,000,000 gallons of mud and water were pumped. It was necessary to install hydraulic pumps in order to liquify the heavy material consisting of mud and clay; and an additional fresh pump was installed to provide the water. In 1915 drainage of the lake was completed except for a certain quantity of clay in the middle of the lake.[1]

The lake has been kept pumped out since that time.

Deep Diamond-Drilling at Crown Reserve

In the summer of 1920, a diamond-drill hole was started on the 500-ft. level of the Crown Reserve mine, the original intention being to continue the drilling to a depth of 2,500 feet[2] below this. When the hole had reached a depth of 1,500 feet it was decided to stop further drilling, no silver-bearing veins having been encountered. This is the deepest point, approximately 2,000 feet below the surface, at which the rocks at Cobalt have been tapped, either by diamond drill or workings of any description. It is thus of interest, although unfortunately the drill did not discover economic deposits of silver or of any other metal.

The drill hole was started on the 500-ft. level in an east and west drift, 330 feet east of the main crosscut. It was directed at an angle of 70° from the horizontal, the course being south about 40° west. The hole was surveyed at various depths and it was found that its intended direction was maintained to the bottom. As originally planned the depth of the hole was such that at 2,500 feet it would have traversed southwestward across the property and have explored the rocks below the productive silver veins all of which had already been practically mined out.

The writer examined the first 1,050 feet of the core.

Briefly stated, the diamind drill passed through fine-grained basalt of Keewatin age for 197 feet, below which it cut a body of medium-grained quartz-gabbro. The drill remained, for the most part, in the quartz-gabbro at least to a depth of 1,050 feet. It is not known whether the quartz-gabbro is an intrusion of Haileyburian age, or whether it is a coarse-grained variety of Keewatin basalt.

The rocks encountered by the drill have no economic significance as far as the further discovery of silver ore is concerned. As a matter of fact the deeper the drill penetrated the farther it retreated from the source of the ore, the source of the ore being the Nipissing diabase. One object which the Crown Reserve management had in mind, when the drilling of the hole was proposed, was to explore for a second sill of diabase below the Nipissing diabase sill. It may be added, however, that the core showed no evidence of a second sill of diabase.

---

[1] Annual Reports, Crown Reserve Mining Company, Limited, 1913, 1914, 1915.

[2] Annual Report of the Crown Reserve Mining Company, Limited, for year 1920.

A description of the rocks encountered by the drill is given more fully in following paragraphs. In connection with the description, about forty thin rock sections of the core were examined under the microscope.

The first 188 feet of the core consist of fine-grained basalt of Keewatin age, showing under the microscope a network of plagioclase rods which are set in a ground-mass of secondary minerals such as chlorite. Here and there are specks and tiny veinlets of iron pyrites, pyrrhotite, and copper pyrites. Veinlets and stringers, fractions of an inch in width, of white calcite occur every few feet.

At a depth of 179 feet 5 inches, the drill passed into a brecciated zone of Keewatin basalt, this zone consisting of fragments of basalt, round and angular, fractions of an inch or more in diameter. The brecciated zone continues to a depth of 200 feet, the last three feet consisting of brecciated quartz-gabbro. Between 180 and 185 feet about three-quarters of the core was lost.

At 197 feet the drill entered a body of quartz-gabbro. It continued to cut this rock to a depth of at least 1,050 feet, with the exception of a few places in which it intersected fine-grained rocks.

Thin sections of the quartz-gabbro from many parts of the core were examined under the microscope, and the rock was found to consist mainly of hornblende and feldspar. There are also microscopic intergrowths of quartz and feldspar, owing to the presence of which the rock has been named quartz-gabbro, Ilmenite altered to secondary material is found. The rock is much more weathered than the Nipissing diabase, and when both rocks are studied under the microscope and compared with each other, there is no difficulty for anyone who is familiar with the rocks at Cobalt to distinguish the two types. The horneblende in the quartz-gabbro is sometimes altered to chlorite, while the feldspar is badly decomposed to secondary minerals. In the Nipissing diabase, on the other hand, the pyroxene and feldspar are generally fresh.

In a few places between 197 feet and 1,050 feet, the rock becomes fine-grained, and it was not determined whether the drill passed out of the quartz-gabbro intrusion or whether the quartz-gabbro became finer in grain.

The quartz-gabbro becomes somewhat acid in places. For instance, the thin section from a depth of 299 feet showed an unusual quantity of quartz; possibly this part of the core might be named a grano-diorite.

Between 420 and 425 feet, the rock is rather fine-grained, although a thin section examined under the microscope from a depth of 422 feet showed it to be a quartz-gabbro.

Between 439 and 450 feet, the rock is fine in grain. A thin section at 439 feet 6 inches shows the rock to be a different type from either the quartz-gabbro or the common basalt of Keewatin age at Cobalt. It consists of fine needles of hornblende set in a feldspathic matrix. No quartz was noted. It is difficult to say whether the drill at this depth, i.e., between 439 feet and 450 feet, passed out of the gabbro into an adjacent rock, or whether it passed through a fine-grained, border phase of the gabbro.

Between 450 feet and 451 feet 6 inches, the core has a banded texture, about a dozen bands, alternately fine and coarse grained, occurring. A thin section at a depth of 451 feet showed irregular grains of feldspar set in a matrix of chloritic material. Cutting across the section is a band consisting mostly of carbonate.

The rock between 451 feet and 6 inches and 507 feet is fine to medium in grain, and is banded in places. The banded structure is suggestive of sediments, although a thin section at a depth of 479 feet 8 inches gave no hint of a sedimentary origin, the rock consisting of fresh plagioclase feldspar and a few grains of quartz set in a matrix of chlorite and a few needles of hornblende. A thin section from 499 feet 6 inches also shows banding, due to alternating bands of fine and coarse grains of quartz and feldspar; whether this is the banding of acidic vein material or of sediments was not determined.

Between 507 feet and 1,050 feet, thin sections show that the drill passed through quartz-gabbro, except at 850 feet, at which point the rock appears to be a lamprophyre.

The quartz-gabbro from the point at which it was first encountered, that is at 197 feet, down to a depth of 1,050 feet is cut by hundreds of calcite veinlets and stringers usually fractions of an inch in diameter.

In a few places sulphides and arsenides were met with. At a depth of 39 feet, the drill cut 8 inches of calcite with which occurred some smaltite. At 178 feet, a three-inch vein of calcite containing a little zinc blende and galena was encountered by the drill. Between 178 feet and 179 feet 5 inches, there is a stringer of calcite three-eighths of an inch wide carrying zinc blende and galena. At 181 feet, there is a two-inch vein of calcite carrying zinc blende.

The plan of the 500-ft. level of the Crown Reserve incorrectly shows the drill hole to have a depth of 1,800 feet.

The chemical analysis of the quartz-gabbro, shown in the following table, was made by W. K. McNeill, Provincial Assayer. The sample was taken from the diamond-drill core at a depth of 1,000 feet below the 500-ft. level.

ANALYSIS OF QUARTZ-GABBRO, CROWN RESERVE

	Per cent.
SiO_2	45.82
Al_2O_3	17.71
Fe_2O_3	0.14
FeO	12.60
CaO	8.66
MgO	4.21
Na_2O	2.33
K_2O	0.80
CO_2	3.37
H_2O (combined)	4.66
Total	100.30

Description of Mine Workings

550-ft., 700-ft., and 800-ft. Levels.—These levels are reached from a winze from the 500-ft. level. The deepest workings in the Crown Reserve are on the north vein, which was discovered in 1912 and which produced about 100,000 ounces of silver. The vein, which is at the north end of the property, is not an important one, but is of interest on account of the depth to which it was worked. The workings on the vein are somewhat isolated from the more productive part of the property and may be considered almost as a separate mine. On the lower levels the company reported that gold was found in the vein, assays as high as $12 per ton having been obtained. The discovery of this gold has proved to be of no economic significance.

The vein was discovered when the crosscut on the 500-ft. level was being driven between the main winze from the Crown Reserve shaft to the Silver

Leaf north shaft as shown on the coloured vertical section facing page 34. The vein strikes eastward and dips about 70° to the south. It varies from a mere crack to about 18 inches in width, and averages probably 3 or 4 inches in width. It consists largely of calcite, but contains also some quartz and a little smaltite. The silver occurred in irregular patches, but the quantity was small; and the writer was given to understand that it scarcely paid to work it. The vein occurs in a fissure, which in places shows a fault breccia as wide as 12 inches and a gouge about an inch wide; but for the most part the gouge and breccia are less than this.

The vein occurs largely in the quartz-gabbro, but it also appears to extend up and into the Cobalt series on the 300-ft. level.

On the 800-ft. level, the rock is largely quartz-gabbro; at the eastern part of the level the rock is fine to medium in grain, and 15 feet west of the east end of the drift the rock is basalt. The vein on the 800-ft. level averages about 4 inches in width, but varies from a crack to 18 inches.

The rock in the winze between the 700-ft. and 800-ft. levels appears to be largely quartz-gabbro.

On the 700-ft. level, part of the rock is quartz-gabbro, two thin sections having been examined under the microscope. The vein on the 700-ft. level varies from a mere crack to 12 inches in width; it averages some 2 or 3 inches. On this level a raise was driven, and at a height of 55 feet above the level the vein was about 6 inches wide at one place where it contained a little high-grade silver ore and smaltite.

Near the east end of the 700-ft. level there is a fault consisting of crushed rock; it was encountered in two places, in the crosscut and about 60 feet west of the east end of the drift. This fault has about the same strike and dip as the prominent fault on the 500-ft. level described below. The mine captain, Mr. Martin, stated that the silver on this level, the 700-ft., appeared to be concentrated at the junction of the fault and the vein.

In the winze between the 700-ft. and 550-ft. levels, there is a fine-grained dike 6 inches wide cutting the quartz-gabbro.

In the winze between the 550-ft. level and the 500-ft. level, the rock is quartz-gabbro and lamprophyre.

500-ft. Level.—The level is reached from a winze on the 300-ft. level about 40 feet north of the Crown Reserve shaft. The Silver Leaf north shaft also goes down to this level, but this shaft has not been in use for some years.

There are two main veins on this level, the Carson and the North veins. The former was drifted on for 200 feet, and, while the vein was continuous for this distance, no silver of economic consequence was encountered.

The North vein strikes eastward and dips at 70° to the south. It contained a few rich patches of silver ore, and although the vein produced, as already stated, 100,000 ounces of silver, it was not profitable. The vein occurs in a fault and varies in width from 2 to 12 inches. The evidence of faulting, namely, the fault breccia and gouge, is not marked on this level, but in the lower workings the faulting is more marked, although the displacement was not worked out.

In the main crosscut about 430 feet south of the Silver Leaf shaft, there is a well-defined fault dipping steeply southeastward. The fault consists of a zone of crushed rock about 2 feet wide, and a gouge up to 2 inches wide. Iron pyrites and other sulphides occur in it. The fault strikes in a northeastward direction. A fault, which appears to be a continuation of this fault, is met with in the east and west drift which follows the North vein. This fault, which is about 250 feet east of the crosscut, intersects the North vein at a gentle angle. The age relationship of the fault to the North vein is a debatable question. It is not clear to the writer whether the fault is older or younger than the vein. The displacement of the fault was not determined.

The rocks on the 500-ft. level are Keewatin and Haileyburian in age. The Keewatin consists of a fine-grained basaltic rock, together with two beds, less than 5 feet thick, of black, fine-grained siliceous carbonaceous "iron formation" carrying iron pyrites. These two beds occur about 45 and 100 feet, respectively, north of the winze at the south end of the main crosscut. A mica-lamprophyre dike of Haileyburian age cuts the "iron formation" bed nearest the winze; this dike is 5 or 6 feet wide and dips about 35° to the northwest. Other lamprophyres are found on this level. The north half of the main crosscut is composed mostly of quartz-gabbro, medium in grain. It is supposed that this quartz-gabbro is of Haileyburian age, although there is no definite proof as to its exact age, except that it is older than the lamprophyre dikes. The gabbro is first seen in the crosscut about 133 feet south of the "North" vein, and it continues north to the Silver Leaf shaft, except where it is cut by a mica-lamprophyre dike. The contact between the quartz-gabbro and Keewatin is not sharply defined. This quartz-gabbro has the same composition as the quartz-gabbro which was encountered in the diamond-drill hole on the 500-ft. level.

450-ft. Level.—The level is mainly in quartz-gabbro together with lamprophyre.

300-ft. Level.—The Carson vein has been drifted on for about 250 feet and found to be 2 to 6 inches wide of calcite and some smaltite. The silver content was not of commercial grade. The vein was further explored by a winze, following the vein, from this level to the 500-ft. level.

The north part of the 300-ft. level, which is distinct from that part on which the Carson vein occurs, is reached by a winze from the 200-ft. level. In this part of the level there is a shallow basin of the Cobalt series resting on the greenstones, the basin striking eastward. The North vein, which roughly parallels the basin, has been stoped, but it has not been followed upwards into the overlying Nipissing diabase. Indeed, the North vein has not been recognized on the 200-ft. level. The vein occurs in a fault showing fault breccia and gouge as wide as one or two feet in places.

No. 17 vein was followed from the 200-ft. to the 300-ft. level by a winze, and on the plan of the 300-ft. level the vein is shown at the winze, striking a little west of north. Vein No. 17 was faulted about 2 feet by the North vein.

A bed of slate-like greywacké at least 7 feet thick is exposed in the stope on the north vein; it is also met with at the west end of the level.

250-ft. Level.—The level is reached by a winze from the 200-ft. level. The contact between the Keewatin and Cobalt series shows that the Keewatin forms a hill on which the Cobalt series is deposited.

200-ft. Level.—This is the most extensive level in the mine, its workings intersecting the rock from the east almost to the west boundary. The exploration of the eastern half of the level proved disappointing. It was hoped that the Fleming vein, for instance, would be a large producer, since on the Kerr Lake mine it was a very important one. As already stated it only produced 176,780 ounces of silver on the Crown Reserve.

At the contact between the Nipissing diabase and the Cobalt series, north of the winze on vein No. 17, there has been faulting. At the winze the bed of slate-like greywacké dips northward at the gentle angle of 4°, but at the contact the bed dips much more steeply, suggesting that the diabase was faulted down, or that the beds were bent down during the intrusion of the diabase, and later faulting along the contact caused a farther bending down of the beds. Elsewhere in this report it is suggested that the diabase was intruded from the southeast to the northwest. At this point in the Crown Reserve, therefore, the diabase was intruded downward across the bedding of the Cobalt series. It cut its way downwards for an unknown distance, then flattened out, and finally rose again, emerging along the Nipissing and O'Brien properties, where it was exposed by erosion.

In the main crosscut north from the Crown Reserve shaft, the diabase was penetrated at the north end of the drift. There is no faulting at the contact, the fine-grained diabase being frozen against the slate-like greywacké, the contact dipping 48° to the north. North of the contact about 22 feet a fault does occur; this fault may be the same one that occurs at the diabase contact north of the winze on vein No. 17.

In the eastern part of the level, our plan shows a fault dipping 20° to 30° to the north. This fault is in the long crosscut, and it occurs in the Cobalt series near the diabase contact.

Judging from these three occurrences it would appear that a fault follows, in a general way, the contact between the Nipissing diabase and the Cobalt series. The work at the Crown Reserve was done in 1920, and at that time the Ontario Department of Mines was not paying the same attention to faults as was later done in 1921, 1922, and 1923, consequently the faults on the Crown Reserve have not been mapped as they should be.

On the 200-ft. level there is also a fault which roughly follows the contact between the Keewatin and Cobalt series. The location of this fault is shown in three crosscuts north of the Crown Reserve shaft. Between the 200-ft. and the 250-ft. levels, there is a fault dipping at about 30°. In places this fault is banded. It contains nodules of iron pyrites.

150-ft. Level.—This level is of interest on account of the fact that vein No. 17 was followed into the Nipissing diabase for about 65 feet, and was found to be unproductive. Vein No. 17 was the second largest producer on the property.

The outlines of the second and third beds of slate-like greywacké are shown. These beds are in places almost horizontal, and in other places dip as high as 19°.

130-ft. Level.—The level is a small one, mainly in veins around the shaft. It is mostly in the Keewatin. The contact between the Keewatin and Cobalt series is indicated by a dotted line.

100-ft. Level.—Difficulty was met with in determining the contact between the Keewatin and Cobalt series at the Carson vein. About a dozen samples of the rock were examined under the microscope, and the Keewatin basalt was found to be much decomposed at the contact. In fact, the contact is the transitional type in which the unaltered Keewatin basalt passes gradually upwards into altered basalt, thence into a basal conglomerate of the Cobalt series in which the fragments are largely Keewatin basalt, and finally into a typical conglomerate of the Cobalt series Under these conditions it is difficult to decide where to place the line of contact. It might be placed at the unaltered basalt, or at the point where the typical conglomerate is developed. We have chosen a line midway between these two extremes, but we will not quarrel with those who are disposed to move the line a few feet to the south.

From one point of view the determination of the contact is important. For instance, on our plans the contact is shown about at the Carson vein, although east of the shaft the contact is below the 100-ft. level at the Carson vein. As this vein has been stoped down to the 200-ft. level, it would seem that some silver must have been obtained from the vein where it occurs in the Keewatin. According to Mr. Samuel D. Cohen, the vein was productive to an average depth of 150 feet.

The north part of the level is largely in a bed of slate-like greywacké, which dips for the most part at angles of 10° or 12° northward.

50-ft. Level.—The Carson vein at the west end splits into two branches which continue into the Silver Leaf a short distance. On the Crown Reserve the barren part of the vein may still be seen, showing in one place 10 inches of calcite.

McKINLEY-DARRAGH-SAVAGE

The McKinley-Darragh-Savage Mines of Cobalt, Limited, has a capital of $2,500,000 in shares of a par value of $1 each. Of this amount, $2,247,692 had been issued. To the end of the year 1922, the company had produced 19,941,726 ounces of silver, including the Savage mine, and had paid $5,955,592 in dividends. The company operates the McKinley-Darragh and the Savage mines, the former having produced most of the ore.

The cost of producing silver during the year 1922 was 54 cents an ounce, or $6.25 per ton of ore. The details of these costs are shown in the following table.

Cost of Producing Silver at McKinley-Darragh[1] in Year 1922

Operations	Total amounts	Per ton of ore mined	Per ounce recovered
Insurance, taxes, administration, etc	$22,032.80	$0.851	$0.0742
General charges at Cobalt	8,644.73	0.334	0.0291
Mining	44,843.51	1.732	0.1510
Milling	44,247.94	1.709	0.1490
Sampling and assaying at Cobalt	2,412.04	0.093	0.0081
Bagging and shipping	1,910.09	0.074	0.0064
Operating camps	682.67	0.026	0.0023
Surface work, roads, etc	1,570.17	0.061	0.0053
Alterations to plant	3,531.55	0.136	0.0119
Prospecting	4.32	....	....
Surface dumps	199.50	0.008	0.0007
Savage	1,310.90	0.051	0.0044
Production costs	$131,390.22	$5.075	$0.4424
Marketing costs $22,243.68			
Less cobalt and copper 7,609.02			
	14,634.66	0.565	0.0492
Shut down costs	15,915.93	0.615	0.0536
Total costs	$161,940.81	$6.255	$0.5452

---

[1] Annual Report, McKinley-Darragh-Savage Mines for year 1922.

The company has compiled the table printed below showing the costs and profits of producing silver from the years 1906 to 1922,[1] inclusive.

COSTS AND PROFITS PER OUNCE OF SILVER RECOVERED, MCKINLEY-DARRAGH

Year	Average price received	Total costs	Net profits per ounce
1906-7	$0.59	$0.2614	$0.3286
1908	0.52	0.2341	0.2859
1909	0.5131	0.2263	0.2868
1910	0.5405	0.1705	0.3700
1911	0.5416	0.19479	0.34681
1912	0.6166	0.1859	0.4307
1913	0.5919	0.2233	0.3686
1914	0.54385	0.31325	0.2306
1915	0.50785	0.28710	0.22075
1916	0.67364	0.40730	0.26634
1917	0.8320	0.5709	0.2611
1918	0.99724	0.6842	0.31304
1919	1.1065	0.7193	0.3872
1920	0.8060	0.8562	Loss 0.0502
1922	0.64995	0.5452	0.10475

The property was closed at the end of the year 1920, and opened again on May 15th, 1922; six weeks later a normal tonnage was being hoisted. During the year 1922 the mill treated 25,848 tons of ore, the mill-heads of which assayed 12.1 ounces of silver per ton.

There are 15.2 miles of underground workings including drifts, crosscuts, raises, winzes, and shafts. The table below, giving a record of the work done, was published in the company's annual report for the year 1922.

EXTENT OF MINING OPERATIONS, MCKINLEY-DARRAGH MINES

Year	Shafts	Drifts	Cross-cuts	Stopes	Raises	Winzes	Station	Trenches
	feet	feet	feet	tons	feet	feet	cu. yds.	feet
1906-7-8	966	4,190	2,971	4,181	301	175		4,000
1909	200	2,007	1,499	7,126	415	81		10,900
1910	106	2,437	2,417	18,084	252	60		150
1911	14	3,256	3,757	36,261	824	93		
1912	85	4,706.5	3,164.5	42,592	632.5	167.5		
1913		4,260	4,088	43,741	857	105		
1914		1,848	4,383.5	39,855	838	170.5		
1915	58.5	2,527.5	1,431	50,753	443	78		
1916	3.5	2,444	1,808.5	39,340	738.5	279.5	238	
1917	14.5	2,408	1,876.5	46,712	374.5	12	240	
1918		4,370	3,433	34,255	441	18		
1919	1	1,340	1,241	27,218	556.5	26		
1920		1,084	1,110.5	38,990	534.5			
1922		113.5	94.5	16,752	112.5			
Total	1,447.5	36,991.5	33,275	445,860	7,320	1,265.5	478	15,050

In the matter of ore reserves at the end of the year 1922, the company reported that there were approximately 20,000 tons of broken ore, and "a considerable tonnage of unbroken ore to be mined."[2]

---

[1] Annual Report, McKinley-Darragh-Savage Mines for year 1922.

[2] Annual Report, McKinley-Darragh-Savage Mines, 1922, p. 4.

The table below, showing the yearly shipments from 1906 to 1922, was compiled by the company in the annual report for the year 1922.

OUNCES OF SILVER SHIPPED FROM THE McKINLEY-DARRAGH MINES, 1906 TO 1922

Years 1906-7	675,656
Year 1908	738,212
" 1909	1,324,704
" 1910	2,621,888
" 1911	2,569,654
" 1912	2,704,868
" 1913	2,228,497
" 1914	1,260,046
" 1915	1,060,136
" 1916	1,055,996
" 1917	1,020,545
" 1918	886,398
" 1919	760,482
" 1920	613,483
" 1922	254,307
Total to January 1st, 1923	19,774,872

The known veins in the McKinley-Darragh were nearly mined out at the time of our examination in 1921, so that very little first-hand information could be obtained regarding them. They form a complex network, particularly well developed on the 150-ft. level. None of the veins extend from the footwall into the hanging-wall of the Cobalt lake fault. One of them on the 400-ft. level is stoped up to the fault, but the writer was informed that the silver content gradually disappeared before reaching the fault. This vein did not extend to the surface.

On the 350-ft. level there is a vein in the Cobalt lake fault which follows the fault for a distance and then gradually leaves it and passes into the footwall. This vein had an ore-shoot which produced approximately 500,000 ounces of silver.

The veins in the McKinley-Darragh are limited on the southeast by the Cobalt lake fault, and as to depth by the Keewatin floor.

In our examination of the mine, we were struck by the fact that there are scarcely any veins now to be seen on the various levels; they have been largely mined with the exception of mill-rock. This appears to show that practically all the veins on the property were productive. These veins are different in this respect from many in the Beaver and Temiskaming mines. At the Beaver and Temiskaming, barren veins are to be seen in some of the drifts; they have in some cases been followed for hundreds of feet, and have been found to be barren of silver, or to have short ore-shoots.

In the annual report of the company for the year 1910, there is an excellent vertical section showing the structural features of the mine. The section shows that the rocks northwest of the Cobalt lake fault have been severely faulted, though the displacement is not nearly so great as is the displacement in the Cobalt lake fault. Veins are shown by the section to occur in these faults. Owing to the nearly worked-out condition of the property at the time of our examination, we were not able to confirm or disprove the presence of these faults in which the veins are shown to occur.

There are two beds of slate-like greywacké, the outlines of which are shown on the vertical section just referred to. Where these beds abut against the Cobalt lake fault, they are bent upwards by the reverse movement of the fault.

Some trouble was met with in mapping the slate-like greywacké on account of the fact that in places it passes gradually into the conglomerate, which makes it difficult to decide as to where the contact line should be drawn on the level plans. An attempt was made, however, to show these beds separately on the plans because of their economic importance. Their importance is due to the fact that where certain veins pass through them, the mill-rock is reported to be of better grade than the mill-rock in the conglomerate. The lower bed of slate-like greywacké rests in places directly on the Keewatin floor, but more generally it is from a few feet to 30 or 40 feet above the Keewatin floor, with conglomerate between the floor and the slate-like greywacké.

If the vertical section facing page 12 be examined by the reader, it will be noted that at the bottom of the mine the conglomerate is over 100 feet thick. Above the conglomerate is the lower bed of slate-like greywacké. On the 250-ft. level this lower bed of slate-like greywacké rests in places, as already stated, directly on the Keewatin floor. It is thus evident that the trough in the Keewatin floor, which occurs below the bottom of Cobalt lake, was first filled with conglomerate to a depth of at least 100 feet. Later on the lower bed of slate-like greywacké was laid down; in the middle of the trough the slate-like greywacké rests on the conglomerate, but higher up the sides of the trough it rests, in places, directly on the Keewatin. A little reflection will make it apparent that this trough in the Keewatin is therefore essentially due to erosion. No doubt the trough was accentuated by folding which took place along the axis of the Cobalt lake fault. This folding is certainly proved by the upturned beds of the slate-like greywacké.

The Cobalt lake fault, which dips 50° to 60° to the southeast, is a reverse one with a displacement of about 550 feet. At La Rose mine the displacement is less, about 275 feet. One might therefore fairly assume from this that the amount of displacement becomes less towards the north.

The writer had a better opportunity to study the Cobalt lake fault at the McKinley-Darragh than at any other property in the area, and it may be described in some detail.

The entire hanging-wall is Keewatin, and the footwall is Cobalt series down to the bottom level. The fault may be said to consist of two parts, first the gouge which is persistent throughout, and second the fault breccia. The fault breccia occurs on each side of the gouge, although most of it is below the gouge in the more easily crushed conglomerate and greywacké of the Cobalt series. The gouge consists of what the miners call a "mud seam", and it varies in width from a quarter or half an inch to an inch or two. It consists of a soft, plastic, clay-like material. The fault breccia consists of crushed and broken rock with some clay and it varies in width from a few feet to 15 or 20 feet or more. The crushed rock becomes less and less crushed as the distance from the gouge becomes greater. It is along the gouge that the movement has taken place. The gouge offered a smooth, greasy plane, along which the movement between hanging-wall and footwall occurred. In the fault in many places there is a calcite vein which reaches an extreme width of 3 or 4 feet, and in which an important ore-shoot of silver was found. This ore-shoot is described below.

An interesting feature of the exploration campaign at the McKinley-Darragh mine is the persistence with which the Cobalt lake fault has been explored. It has been systematically developed on six levels for a total distance of between 6,000 to 7,000 feet. No doubt the reason for so much work along the fault was the discovery of the valuable ore-shoot mentioned above, which was found in the fault between the 350-ft. and 300-ft. levels. This ore-shoot partly follows the fault, and then gradually leaves it and runs into the conglomerate; at its southwest end the vein is about 3 or 4 feet or more northwest of the gouge. As already stated, according to information received from the management, this ore-shoot produced approximately 500,000 ounces of silver.

From the plans of the McKinley-Darragh levels, and from the vertical section facing page 12, it will be seen that on lower and lower levels the width of the productive formation, the Cobalt series, becomes less and less, until on the 400-ft. level it has an average width of only 135 feet; on the 450-ft. level it is reported to be more narrow still.

The Keewatin consists mainly of basalt, although there is some Keewatin "iron formation." The contact between the Keewatin basalt and the Cobalt series is generally transitional, but the contact between the "iron formation" and the Cobalt series is often sharp and well defined.

On the surface of the property a small remnant of the bottom of the Nipissing diabase sill was found in the railway cutting. This patch is about 15 feet wide and at least 40 feet long, being covered with drift towards the Cobalt lake fault. It is interesting to find this patch here. It corresponds structurally to that at La Rose, but at La Rose it is much larger.

Description of McKinley-Darragh Workings

450-ft. Level.—This level was not accessible; the following information was obtained from the company. A vertical winze was sunk from the 400-ft. to the 450-ft. level, and a crosscut was run southeast about 75 feet where it encountered the Cobalt lake fault. The fault was then drifted on about 200 feet to the northeast, and about 125 feet to the southwest. Near the southwest end of the drift, there is an inclined raise along the fault up to the 400-ft. The Keewatin was encountered in the lower part of the winze. The crosscut from the winze to the fault was said to be in Keewatin for some distance southeast of the winze, after which it entered the Cobalt series and remained in this series up to the Cobalt lake fault.

400-ft. Level.—The Cobalt lake fault has been explored by a drift on this level for about 900 feet. A calcite vein occurs in places in the fault; the vein is 4 feet wide at one point, but contains no silver. In many places in the gouge and in the crushed rock beside the gouge there is cobalt bloom, and in one place some smaltite. Here and there much rusty material occurs which may be altered iron pyrites. For long distances, 50 to 100 feet, there is no calcite vein in the fault. Towards the northeast end, the fault contains much graphitic material. The rock is very badly crushed at this end, and the cost of mining the drift was therefore low.

In a number of places in the mine, there are veins which run towards the Cobalt lake fault at right angles, such as vein No. 70 on the 400-ft. level, east of the shaft. The vein became weaker as it approached the fault, and it is reported that the silver content disappeared before it reached the gouge of the fault. An interesting feature of this vein is that it is a blind one, and does not reach the surface. It is thus limited by the Keewatin floor below, by the Cobalt lake fault on the southeast, and vertically by the fact that it pinches out.

350-ft. Level.—The most interesting feature of this level was the occurrence of an ore-shoot, the northeast end of which was in the Cobalt lake fault; that is to say, the vein rested directly against the gouge at the northeast end, but towards the southwest the vein gradually left the gouge until, at the southwest end of the drift, it was 3 or 4 feet or more northwest of the gouge. All of the silver-bearing portion of this vein has been mined except a small pillar about 3 or 4 feet square. It is in this pillar that the vein may still be seen resting directly against the gouge of the fault. This vein is about 2 or 3 inches wide in the pillar and consists of smaltite, niccolite, native silver, and calcite. At the southwest end of the vein, the unproductive part may still be seen in the back of the stope about 15 feet or so above the floor. The vein here consists of smaltite and calcite, and in places there are two or more parallel veins. Fig. 2 is a photograph of the stope, showing the hanging-wall of the Cobalt lake fault.

The productive part of the vein extended 20 feet below the level and rose a maximum 50 feet above the level, a total vertical distance of 70 feet. The length of the ore-shoot was about 275 feet. The width of the vein was a few inches, but it was said to be in one place as much as 5 feet in width, 2 feet of which was high-grade ore. This rich part was about 12 feet long. The company reported that the ore-shoot yielded about 500,000 ounces of silver.

Southwest of this ore-shoot a calcite vein in the Cobalt lake fault attains a width of 2 feet, and it carries in places some iron pyrites and other sulphides.

About 270 feet southwest of the main shaft there is a vein-system striking southeast towards the Cobalt lake fault. The stope on this vein-system comes up to the fault, but we were not able to find out whether or not the ore-shoot in the vein extended as far as the fault.

At 185 feet from the northeast end of the Cobalt lake fault, there is an almost vertical fault running into the Cobalt lake fault at an angle of about 30°.

At the southwest end of the property, there is a vein in the Keewatin series which is said to contain good mill-rock. The vein extends up to the 300-ft. level.

300-ft. Level.—This level has a drift along the Cobalt lake fault for almost a quarter of a mile. An interesting feature of the fault is that at the southwest end there are horizontal striations in the walls of the gouge, indicating some horizontal movement.

At the southwest end of the mine, a bed of slate-like greywacké abuts against the Cobalt lake fault, and the beds have been thrust up in the manner commonly seen in reverse faults. The bed begins to tilt up 30 feet from the fault. Near the fault the bed dips at 50° to 70° to the northwest.

This level is characterized by a bed of slate-like greywacké, finely bedded and having a thickness of from 10 to 25 feet. It does not occur on the lower levels. The bed is generally separated from the Keewatin by a bed of conglomerate and greywacké from 5 to 15 or 20 feet thick.

In the northeast part of the Cobalt lake fault, cobalt bloom occurs almost continuously along the gouge for about 300 feet. At one place some smaltite was found in the gouge, and there is a stope in this part of the vein in which a small quantity of silver was found. The vein is clearly younger than the fault.

250-ft. Level.—A feature of this level is the manner in which the bed of slate-like greywacké for a thickness of about 8 feet has been mined in a manner similar to that in which a gently dipping coal seam is mined. The bed dips at an angle of about 15°. The mining of this bed of slate-like conglomerate is due to the peculiar manner in which the "Lake" vein occurs. A glance at Fig. 25 will explain its character. The Lake vein descends vertically to the slate-like greywacké; then, by a series of "steps," passes through the bed. The slate bed was impregnated with native silver, and it was thus possible to mine about 8 feet of the bed. The vein in the Seneca was affected in a similar manner when it encountered a bed of slate-like greywacké (Fig. 32).

There is a crosscut about 800 feet long running southeast from the shaft and intersecting vein No. 7, the Kendall. The crosscut intersected Keewatin basalt southeast of the Cobalt lake fault. The Keewatin was cut by coarse-grained lamprophyre dikes. The Kendall vein on this level is 7 to 8 inches wide of calcite.

200-ft. Level.—An interesting feature is the occurrence of a fault similar to the "contact" fault on the Coniagas. It occurs in the conglomerate a few feet above the Keewatin, and we were able to trace it for 600 feet. It is most prominent at the southwest end of the mine, and becomes weaker towards the notheast. This fault was also noted on the 250-ft. level.

150-ft. Level.—The contact between the Keewatin and Cobalt series on this level is much more irregular than on any lower level. The contact shows the Keewatin floor to consist of two prominent hills with intervening troughs. This irregularity is due to erosion in the Keewatin before the Cobalt series was laid down. If the troughs were due to folding after the Cobalt series was laid down, the Cobalt series would also be folded. Such minor folding as there is does not conform to the Keewatin troughs.

This level has more development work done on it than has any other level, and it is the most productive.

An attempt has been made to show the outlines of two beds of slate-like greywacké. It was found to be an unsatisfactory piece of mapping, but, in view of the structural importance of the beds, it was thought advisable to map them as best we could in the time at our disposal. The upper bed is thicker than the lower. Where the upper bed abuts against the Cobalt lake fault, the bed is tilted up at angles as high as 50° or 60°.

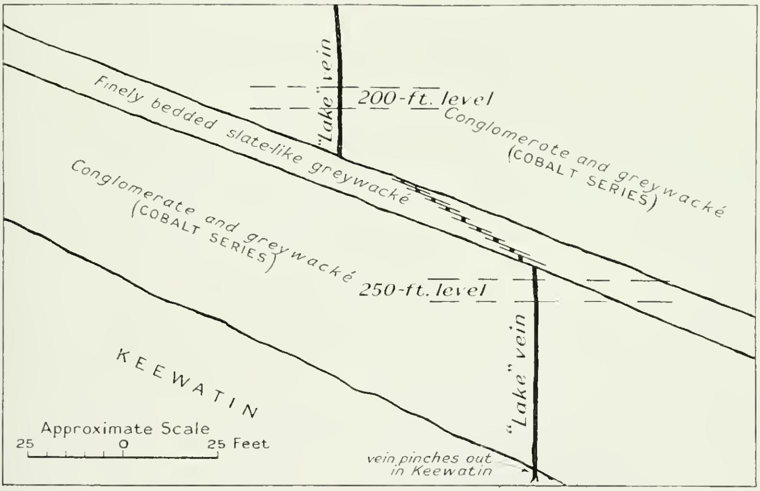

"Lake" vein
200-ft. level
Finely bedded slate-like greywacké
Conglomerate and greywacké (COBALT SERIES)
Conglomerate and greywacké (COBALT SERIES)
250-ft. level
"Lake" vein
KEEWATIN
Approximate Scale
25 0 25 Feet
vein pinches out in Keewatin

Fig. 25—Sketch illustrating what happens to the "Lake" vein, McKinley-Darragh mine, when it passes from conglomerate and greywacké into a bed of finely-bedded, slate-like greywacké.

At the northeast end of the Cobalt lake fault, there is a barren calcite vein about an inch wide containing cobalt bloom. The vein strikes towards the Cobalt lake fault at right angles. Where it enters the fault it splits into three or four small stringers. These stringers gradually change their strike and, in place of running directly into the gouge at right angles, they gradually turn and finally follow the gouge itself. It would appear that this vein is a subordinate fracture from the Cobalt lake fault.

110-ft. Level.—The Keewatin has not been encountered on this level, nor do the workings extend to the southeast far enough to intersect the Cobalt lake fault. There is much slate-like greywacké on the level, but, owing to the fact that many of the workings are inaccessible, it was not found practicable to map it. The slate-like greywacké is resting at gentle angles, in places 5° to 10°.

75-ft. Level.—An interesting feature of this level is the occurrence of a silver-bearing vein in the hanging wall of the Cobalt lake fault. The vein is about 4 feet to the southeast of the fault. It is said to have produced about $25,000 in silver. The vein may still be seen in the back of the small stope where it consists of 3 or 4 inches of smaltite and calcite, together with a little niccolite.

60-ft. Level.—The workings on this level are not extensive. The rock is conglomerate of the Cobalt series. What is known as the "first swamp" vein occurs on the level. The vein is now stoped out.

Kendall Vein.—No. 7 vein, the Kendall, on the 60-ft. level of No. 7 shaft, occurs at the southeast part of the property. The vein is known as the Kendall vein on the Nipissing, on which property most of the ore was obtained. This is due to the fact that the conglomerate on the McKinley where the vein occurs is but 14 feet deep in the shaft. While the vein in the Keewatin is a strong vein, 1 to 12 inches wide, of calcite and a little quartz, and has been explored for 250 feet in depth, it was not commercially productive in the Keewatin rocks, although some rich patches were found. One of these rich patches in the vein may still be seen on the 60-ft. level.

The No. 7 vein was worked from the No. 7 shaft from the 60-ft. and 100-ft. levels. A long crosscut from the 250-ft. level of the main shaft was driven about 800 feet southeast and intersected this vein, where it was found to be a strong one consisting of 7 to 8 inches of calcite. In the Cobalt series the vein was about vertical, but on entering the Keewatin it dips southward at a steep angle. Where we observed the vein in the Keewatin it occurs in a minor fault.

SAVAGE

The Savage mine is owned by the McKinley-Darragh-Savage Mines of Cobalt, Limited.

The vein-system consists of a number of parallel veins striking northeastward, as shown on the plans. The ore-shoots are confined to the southeastern half of the property where the conglomerate is shallow. The veins do not contain ore in the Keewatin nor does the ore as a general rule extend to the surface. It is probable that the Keewatin floor influenced the deposition of the silver ore-shoots, as it has elsewhere in the Cobalt area. The chimney-like form of some of the ore-shoots is a feature of the Savage ore bodies.

A characteristic of the ore bodies is that the silver has not extended into the wall-rock as far as it has, for instance, at the Coniagas, McKinley-Darragh, or other properties. Hence the stopes are narrow, ordinarily the width of a drift.

Much development work has been done on barren veins.

The fractures in which the veins occur are in places open for a width of 4 or 5 inches.

The conglomerate of the Cobalt series is a very coarse boulder variety; boulders a foot or two in diameter are common. One bed of slate-like greywacké was noted which in places rests directly on the Keewatin floor, as it likewise does in the Provincial mine immediately west of the Savage.

The Keewatin appears first on the 140-ft. level near the south boundary; this level produced the greater part of the ore.

The descriptions of the levels, beginning with the 240-ft., may now be given. These descriptions are substantially from the field notes of Mr. James Hill, who geologically mapped and reported on the mine for the Ontario Department of Mines.

290-ft. Level.—The level was flooded at the time of examination. No. 2 vein was explored, but was found to be non-productive. The rocks are reported to belong to the Cobalt series.

240-ft. Level.—No. 2 and No. 10 veins have been opened up on this level. No. 10 was inaccessible at the time of examination, but was said to occur in Keewatin rocks and to be stoped for 120 feet. No. 2 vein was not accessible east of the winze. It is reported to have contained low-grade ore for 440 feet. Lenses of smaltite 3 inches wide were noted in No. 2 vein at the winze.

In the drift on No. 2 vein, a bed of slate-like greywacké may be seen resting on Keewatin at the winze. At the west end of the winze, the bed of slate-like greywacké dips 9° westward, and is about 15 feet thick. In the crosscut north of the winze, the greywacké bed dips northward.

190-ft. Level.—Only part of the workings around No. 2 vein were accessible. This vein was stoped for 100 feet in length, and its branch 70 feet; the latter is also stoped on the Provincial. On the Savage the branch of No. 2 vein occurs in a minor fault.

No. 10 vein is reported to have been stoped for 180 feet in length. Vein No. 23 produced some rich ore and has been stoped for about 80 feet.

The level is reported to be in conglomerate except in the vicinity of vein No. 6.

140-ft. Level.—Veins Nos. 3, 4, 5, 6, and 7 produced most of the ore which came from this level. No. 10 vein was richest from this level upwards, but yielded a greater tonnage below the level. The stopes average only 4 to 5 feet in width, as the silver did not penetrate the wall rock as far as it usually did in many other mines in the Cobalt area. A notable feature of the productive part of the veins is their chimney-like form. No. 10 vein, with a productive length of only 40 feet, yielded very rich ore. The ore-shoot of No. 23 vein was also chimney-like in form, the ore occurring below the level. The stope of No. 4 vein was 180 feet long; that of No. 3 vein was 130 feet long; that of No. 6 vein was 130 feet long; and No. 8 vein 200 feet long.

The level is almost entirely in conglomerate of the Cobalt series; much of the conglomerate is of the coarse boulder variety.

The Keewatin was met with in No. 6 and No. 11 crosscuts. In No. 6 crosscut the Cobalt series rests on a lamprophyre dike.

80-ft. Level.—None of the veins except part of No. 4 reach the surface. No. 4 vein was stoped for about 260 feet, and No. 3 for 250 feet. No. 5 and No. 6 veins produced little ore on this level. The level is all in conglomerate of the Cobalt series.

O'BRIEN

The O'Brien mine is owned by M. J. O'Brien, Limited, the head office of which company is in Ottawa, Ontario.

It has not been the policy of this concern to publish annual reports, the company being a close corporation; hence the costs of mining and treating the ore have not been made public, and the following account of the property is not as full as it might otherwise be.

The mine has produced 18,342,603 ounces of silver to the end of 1922, but the profits or dividends which have been paid from this substantial yield have not been made known.

About three-quarters of the silver, according to information furnished by the company, has been obtained from veins occurring in the Nipissing diabase sill; these veins occur along the bottom of the sill. The rest of the silver produced was obtained from veins in the Cobalt and Keewatin series in about equal proportions. Thus, it may be said that the Nipissing diabase sill is economically the most important formation at the O'Brien mine, since it is responsible for three-quarters of the output of silver.

In the fall of 1921, the O'Brien was reported to be mining ore in No. 20 winze workings at a depth of 800 feet below the collar of No. 6 shaft. The ore at this depth was said to be largely a good grade of mill-rock, although some high-grade ore was also reported to have been mined. This ore occurs along the contact between the bottom of the Nipissing diabase sill and the underlying Keewatin.

In 1918 the company obtained most of its ore from the Keewatin basalt. In regard to this matter E. A. Collins reports: "It may be noted that of the ore broken [in 1918] 3,484 tons came from the conglomerate, 18,980 tons were in diabase, and 26,800 tons were mined in the Keewatin below the diabase sill."[1]

There are three main vein-systems on the property, the No. 1, No. 6, and No. 20. Veins Nos. 1 and 6 strike between eastward and southeastward, are roughly parallel and about 500 feet apart. Towards the southeast, the two veins tend to approach each other, and to split into a number of branches. Vein No. 20 runs southeastward from vein No. 6.

No. 1 vein is probably the longest vein in the Cobalt area; it is the eastward extension of the McDonald vein on La Rose. If the veins on the Violet eventually prove to be the eastward extension of the O'Brien No. 1 vein-system, then the total length of this vein-system (including the McDonald on La Rose, the No. 1 vein on the O'Brien, and the Violet veins) will be about two-thirds of a mile. One of the stopes in this vein-system on the O'Brien is 900 feet long on the second level of No. 1 shaft. This stope extends into La Rose at least 445 feet.

While the No. 1, No. 6, and No. 20 veins are the principal veins on the property, there are a number of others of much less importance, the locality of which may be seen on the sheet showing the O'Brien, Violet, and Colonial workings.

The O'Brien mine is a good illustration of how the silver ore-shoots follow, in a general way, the contact of the bottom of the Nipissing diabase sill. The ore-shoots have been proven to occur within a zone about 100 feet above or below the bottom of the Nipissing diabase sill, but some of the shoots do occur as far as 200 feet above or below the bottom of the sill.

The bottom of the Nipissing diabase sill dips at angles of 10° to 25° eastward, but the dip becomes steeper on lower levels.

Since the ore-shoots follow the dip of the bottom of the diabase sill downwards, the surface outcrops of the veins towards the east are represented by little else than joint planes.

Generally speaking, it may be said that at the O'Brien, if there are ore-shoots in the Cobalt series between the bottom of the Nipissing diabase sill and the Keewatin, very little silver descends to the Keewatin; but, if the Cobalt series is absent, then ore-shoots may descend from the bottom of the Nipissing diabase sill down into the Keewatin basalt.

The stopes in the O'Brien mine examined by the writer are generally narrow, averaging between 5 and 10 feet in width. At junctions of two or more veins, however, the stopes are in places 15 to 20 feet in width. The stope at the west end of No. 1 vein, on the 50-ft. and 100-ft. levels, is as wide as 20 to 35 feet in places; this stope is in conglomerate and greywacké of the Cobalt series. The width of this stope may be seen in the open cut at the west end of the vein. The maximum depth of the conglomerate in this stope is about 100 feet.

---

[1] Annual Report, Ont. Bur. Mines, Vol. XXVIII, pt. I, 1919, p. 146.

The most prominent fault on the property is what has been called the O'Brien fault, which strikes between west and northwest. It has been encountered on the fourth, fifth, sixth, and seventh levels. The fault is about vertical, dipping 80° to 85° to the south, in places dipping locally to the north. It is similar in character and strike to the Violet fault on the east, and to the fault on the Chambers-Ferland, Nipissing, and Hudson Bay to the west. On the O'Brien it was reported to the writer that the fault yielded no silver.

About 100,000 ounces of silver had been obtained from veins north of the O'Brien fault to the end of the year 1921, this production having come from mill-rock containing 15 to 25 ounces of silver to the ton. Little high-grade ore of any consequence was mined north of the O'Brien fault.

The workings of the O'Brien mine, shown on the O'Brien, Violet, Colonial sheet, are, unfortunately, not complete. About three-quarters of the workings are shown. This is owing to the fact that at the time of our examination of the O'Brien, in the fall of 1921, a strip of land between the O'Brien and Violet mines was under litigation. In consequence of this lawsuit, the O'Brien workings in this disputed strip are not shown on our plans. Nor do the plans show the workings below the seventh level. These workings below the seventh level are from winze No. 20 and follow the extension of vein-system No. 20 along the contact between the bottom of the Nipissing diabase sill and the Keewatin basalt.

Description of O'Brien Mine Workings

At the end of the year 1921, there was a total of about 12 miles of drifts' crosscuts, raises, winzes, and shafts.

Workings below Seventh Level.—There are reported to be about 4 or 5 miles of drifts, crosscuts, winzes or raises in the workings below the seventh level. The lowest level is 800 feet below the collar of No. 6 shaft. At the request of the management, the Ontario Department of Mines did not make a detailed examination of these workings, nor are the plans published in this report. A few hours were spent with the assistant manager in a casual examination, and it was observed that on one of the lower levels the contact of the bottom of the Nipissing diabase sill with the Keewatin was at one place very steep—in the neighbourhood of 60° or more

From time to time, since the year 1914, certain information regarding these lower workings has been published in the reports of the inspectors of mines for the Province of Ontario. For convenience this information is given below.

In 1915, J. G. McMillan[1] reported as follows:—

> During the year [1914] the winze [No. 20] from the 300-ft. level of the No. 6 shaft was sunk to a depth of 200 feet, cutting the diabase-Keewatin contact at 180 feet, or 480 feet from the collar of the shaft. In this winze three levels have been opened, some new ore put in sight, and ore proved to exist below the lowest level.

In 1916, James Bartlett[2] reported:—

> The winze, No. 20, from the 300-ft. level of No. 6 shaft has been sunk to a depth of 250 feet and four levels have been opened.

In 1917, James Bartlett[3] wrote:—

> A new level was established at 610 feet.

---

[1] Annual Report, Ont. Bur. Mines, Vol. XXIV, pt. I, 1915, p. 121.

[2] Ibid, Vol. XXV, pt. I, 1916, p. 119.

[3] Ibid, Vol. XXVI, 1917, p. 123.

In 1918, E. A. Collins[1] reported as follows:—

> A new low level was established at 720 feet below the collar of the main shaft and ore mined at this level.

In 1919, J. G. McMillan[2] reported:—

> During the year a new winze level was established at 800 feet below the collar of No. 6 shaft.

Seventh Level.—(700 feet above sea level at main shaft.) Vein No. 6 at the west end in the Keewatin occupies a fault dipping 50° to 60° north, and having a fault breccia and gouge 2 or 3 inches to a foot or more in width. In places there is a quartz and calcite vein in the fault, but the vein has not been productive in the Keewatin. Where this vein enters the diabase about 350 feet east of No. 6 shaft it becomes productive, and a stope some 300 feet in length has been developed. The stope is about vertical, so that as vein No. 6 went from the Keewatin into the Nipissing diabase it evidently became vertical and, also, productive of silver. The fault is in the Keewatin series; we were not able to observe if this fault enters the diabase, but it was observed that farther southeast this vein is not in a fault.

Vein No. 6 pinches out about 50 feet northwest of No. 20

No. 20 vein is an important one, and has a stope on this level about 250 feet long. This stope begins at winze No. 20, and is wholly in the Nipissing diabase on this level.

For about 500 feet east of the main shaft, No. 1 vein in the Keewatin is for the most part only fractions of an inch in width, consisting of calcite. As the vein approaches the Nipissing diabase it becomes wider, and finally ore develops in it; a stope three or four hundred feet long has been mined. A vein of unusual shape crosses at right angles the No. 1 vein near the east end; this vein forms a huge semi-circle, and has a stope some 600 feet long.

At the north end of the workings there is a vein striking about east and west which follows the north side of a small lamprophyre dike. This vein was not productive on the seventh level, but was being stoped on the level above in October, 1921. The ore was not high-grade, but was a fair grade of mill-rock.

The rocks on the seventh level consist largely of the Keewatin series with a smaller development of the Cobalt series and Nipissing diabase at the east end. The Keewatin is made up of basaltic rocks, except at the north part of the workings where finely bedded cherty rocks of the "iron formation" occur. The Cobalt series at the northeast part of the level consists of easily recognizable conglomerate and greywacké, but towards the southwest the Cobalt series consists of decomposed Keewatin which is difficult to distinguish from the Keewatin along the contact.

The O'Brien fault is met with in a crosscut about 150 feet north of No. 1 vein. The fault consists of about 15 inches of fault breccia and gouge, and it contains a little galena, zinc blende, and iron pyrites; it dips steeply south. The fault follows the contact between the finely bedded cherty rocks of the "iron formation" on the north and the basalt on the south.

Sixth Level.—(755 feet above sea level at main shaft.) The contact between the Nipissing diabase and the Keewatin occurs in No. 6 shaft about 13 feet above the level. In the vicinity of No. 6 shaft it may be seen that vein No. 6 is vertical in the Nipissing diabase and that, when it descends and enters the Keewatin, it dips at about 50° to the north. It would appear that the vein in the Keewatin follows an old fissure of pre-diabase age. The fissure shows an inch or two of fault breccia and contains quartz which is probably older than the calcite. For 500 or 600 feet in the vicinity of winze No. 20, the No. 6 vein is little else than a vertical joint plane in the diabase containing fractions of an inch of barren calcite. The southeast face of this drift shows a crack containing a little gouge. This part of the vein southeast of winze No. 20 is evidently too high above the contact between the diabase and Keewatin to be productive. The vein is for the most part frozen to the diabase walls. East of No. 6 shaft there is a stope in the diabase 250 feet long.

---

[1] Annual Report, Ont. Bur. Mines, Vol. XXVII, pt. I, 1918, p. 125.
[2] Ibid, Vol. XXIX, pt. I, 1920, p. 104.

Vein No. 1 just east of the main shaft splits, the two branches continuing eastward for about 200 feet and eventually joining again. The two branches contain usually less than one inch of calcite. Opposite the shaft the vein is 3 or 4 inches in width of calcite.

Vein No. 16 strikes about northward. It has 2 stopes, one about 275 feet long, and the other less than 100 feet long. The O'Brien fault crosses vein No. 16 about at right angles. For 20 or 30 feet on the north and south side of the fault, vein No. 16 appears to pinch out save for irregular stringers.

The O'Brien fault occurs near the north end of the level, and has been drifted on for nearly 400 feet, but no ore was found. Galena, iron pyrites, zinc blende, and a very little calcite occur in it. The fault contains from one-half to three-quarters of an inch of gouge, and 1 to 4 feet of fault breccia. It strikes W. 16° N. and dips 70° to 75° south; locally it dips to the north.

The rocks on this level consist of Keewatin and Nipissing diabase in about equal proportions, together with a belt of the Cobalt series. The Keewatin is made up largely of basalt, but at the north end of the level it consists of "iron formation" having a width of at least 300 feet. The "iron formation" is made up of chert, greywacké, and quartzite-like rocks. The "iron formation" dips steeply southward, and strikes westward about parallel to the O'Brien fault. Indeed, the O'Brien fault on this level and the seventh follows the contact between the "iron formation" and the Keewatin basalt.

This "iron formation" was found on the Violet mine to the east of the O'Brien.

Fifth Level.—(850 feet above sea level at main shaft.) This is the most extensive level in the mine, reaching as it does almost from the north end to the south end of the property. The noteworthy piece of development work is a crosscut almost half a mile long in the Nipissing diabase, intersecting veins No. 1 and No. 6, and some others which were not productive.

On vein No. 6, just west of No. 6 shaft, there is a stope about 500 feet long for the most part in the diabase, while at the west end of the vein there is a small stope 150 feet long which is in the Keewatin.

On No. 1 vein there is a stope about 300 feet east of the main shaft; this stope is in the diabase and is about 150 feet long.

Vein No. 16 has been stoped up to the surface, and the upper part was being worked as an open pit in the fall of 1921.

On the plan of the fifth level, there are shown certain workings at the north-east end of the O'Brien property. These workings are not connected with the main shaft on this level; but the workings may be reached from No. 14 shaft, or by going up a raise from the sixth level at the north end. Vein No. 16 and a vein farther east have been worked from this level, with small stopes, partly on the Nipissing property and partly on the O'Brien property. The workings are all in the Cobalt series except at the east, and where a drift just enters the Nipissing diabase.

The fifth level workings are connected with the No. 33 shaft at the southwest corner of the property; and the second level of the No. 33 shaft corresponds to the fifth level of the main shaft. The fifth level at the No. 33 shaft was run to work vein No. 33, which was followed for 500 feet. In places this vein attains an unusual width—from 12 to 15 inches of white calcite. The contact of the Nipissing diabase and Keewatin basalt occurs at the shaft, and is irregular in outline as the plan shows.

There are a number of interesting faults on this level, chief of which is the O'Brien fault at the northeast end of the level. Here the fault is in the Nipissing diabase, and has been followed for some 50 feet. It has an unusual dip on this level, 75° to the north, whereas, as a general rule, it dips to the south. The fault breccia and gouge is about one foot wide and, in places, the rock is crushed for four or more feet. The rock falls readily from the back, making mining operations dangerous.

Southwest of No. 6 shaft 650 feet, there is a minor fault striking a little north of east. The gouge and fault breccia are from half an inch to about 3 inches in width, being widest at the east end. Possibly this fault explains the presence of the valley on the surface in this part of the O'Brien. Cutting about at right angles to this fault, there is another one about 30 feet west of the main crosscut. The fault shows from 1 to 3 inches of gouge and breccia and appears to strike about parallel to the diabase contact. A similar fault to this occurs at the south end of the property, and it also strikes about parallel to the diabase contact.

Fourth Level.—(885 feet above sea level at main shaft.) No. 1 vein has been drifted on for about one-quarter of a mile. This vein is almost wholly in the Keewatin basalt. Where examined, it is but a few inches in width and, at the east end, it pinches out to a mere joint crack. The west end of the level was flooded and inaccessible. West of the main shaft there is a stope about 200 feet long in Keewatin. From this stope west to No. 1 shaft there are no other stopes.

The O'Brien fault was met with on this level at the northeast part of the workings and was followed for about 300 feet. It strikes about W. 20°N. and dips 85° to the south, although locally it is practically vertical or even dips steeply to the north. The fault has about a foot of fault breccia and gouge, and a vein of calcite about an inch wide occurs here and there in the fault. In places the fault is rusty.

A crosscut runs northward from the fault, passing No. 14 shaft, to the north boundary between the O'Brien and Nipissing properties. Exactly on the boundary line there is an east and west crosscut 600 feet in length, the cost of which was shared jointly by the O'Brien and Nipissing companies. The Keewatin was encountered at the west end of this crosscut, consisting of rusty cherty rocks of the Keewatin "iron formation."

Third Level.—(No. 6 shaft, 921 feet above sea level at No. 6 shaft and 75 feet below collar of No. 6 shaft.) This level was worked originally from No. 6 shaft. It is, as a matter of fact, the first level from No. 6 shaft, but is known as the third level. No. 6 vein has been drifted on for nearly 1,500 feet. Immediately west of the shaft, there is a stope nearly 500 feet long in Nipissing diabase; at the west end there is a stope about 450 feet long which is in Keewatin.

In places where No. 6 vein could be seen, it varied in width from fractions of an inch to six inches or a little more. Part of the stope at the west end was accessible, and in the back the vein was seen to be in places as wide as six inches. The stope was 5 or 6 feet wide.

At the west end of the drift, there is a fault of importance with a fault breccia and gouge of three or four inches. The fault dips to the north about 55°, and the vein appears on each side of the fault; what the displacement of the vein has been, if any, was not apparent.

The rocks on the level are Keewatin basalt and Nipissing diabase in about equal proportions.

Third Level.—(No. 1 shaft, 929 feet above sea level at No. 1 shaft, 150 feet below collar of No. 1 shaft.) This level was not examined, nor is it shown on our plans. It has a length of 265 feet; there is a stope west of the shaft 60 feet long, and a stope east of the shaft 30 feet long.

Second Level.—(No. 1 shaft, 979 feet above sea level at No. 1 shaft, 100 feet below collar of No. 1 shaft.) The stope on No. 1 vein on this level is 900 feet long, partly in rocks of the Cobalt series, and partly in Keewatin rocks. At the east end of the stope there is a fault dipping at some 20° or 30° to the east. No ore has been found above the fault in this part of the mine. In other words, this fault limits the eastward extension of the ore. The vein continues eastward, but does not become productive again for some distance east of the main shaft. This fault is another instance of how a fault limits the deposition of the silver ore at Cobalt.

In the vicinity of the fault, at the east end of the drift, there is on the walls of the drift in places a thin coating or film of bluish-black, oily-looking material. A sample of this material was taken by scraping it off the walls of the drift. In doing this, much of the finely powdered rock which clings to the walls of all mine workings in Cobalt, was mixed with the sample, so that the quantity of the bluish-black material in the sample was small compared to the quantity of powdered rock. But, in spite of this dilution, the sample was found to contain 100 ounces of silver to the ton. It is quite evident that this coating is of secondary origin and has been deposited on the walls of the drift after mining operations had ceased. No mining has been done in this part of the drift for five or six years.

Material similar to this was first noted at the Crown Reserve mine about ten years ago. At that time a sample was submitted to W. K. McNeill, Provincial Assayer for Ontario, who considered the material might be a mechanical mixture of finely powdered, silver-bearing minerals. In the old workings of other mines at Cobalt, this material has also been observed occurring under similar conditions.

The level is in the Keewatin and Cobalt series. The Keewatin "iron formation" is present. The contact between the Cobalt series and Keewatin is in the shaft a few feet below the level.

First Level.—(No. 1 shaft, 1,029 feet above sea level at No. 1 shaft, 50 feet below collar of No. 1 shaft.) This level is now mostly an open cut nearly 500 feet long, all in conglomerate and greywacké of the Cobalt series. At the west end, two veins, striking southward from the Chambers-Ferland, join the No. 1 vein. In the vicinity of the junction the open cut is about 35 feet wide.

The level is all in conglomerate and greywacké of the Cobalt series except at the south end of a crosscut at the east end of the level where there is about eight feet of Keewatin.

Workings from No. 2 Shaft.—This shaft is 900 feet south of the northwest corner of the property. It was sunk in order to mine the southeastward extension of La Rose veins known as Nos. 3 and 6. On the O'Brien property these veins are unfortunately all in the Keewatin series.

At the time of our examination, in October, 1921, only the first level was accessible. There are four levels.

The first level is 65 feet below the collar of the shaft. There are half a dozen veins on the level, all of which are in Keewatin basalt. The most westerly one has been drifted on for about 275 feet, and there is a small stope at the south end; the vein shows one or two inches of calcite. East of the shaft another vein has been drifted on for about 200 feet, and there is a stope about 100 feet long. This stope goes to the surface and shows the vein to have an unusually flat dip—at the south end 35° to 38°, at the north end a little steeper.

At the east end of the workings, there is a well-defined fault which has been followed for about 100 feet; it strikes northeast and dips about 25° to the northwest. The fault shows an inch of gouge in places, and from six inches to two feet of fault breccia. A calcite vein, three or four inches wide, shows in the back of the drift; its relation to the fault was not noted.

In several places there are lamprophyre dikes on this level.

Workings from No. 33 Shaft.—This shaft is at the southwest corner of the property. There are two levels, at 100 feet and 180 feet below the collar of the shaft. The 180-ft. level has been described in dealing with the fifth level.

The first level from No. 33 shaft follows a vein for 400 feet. The vein strikes southwestward and occurs in the Nipissing diabase at the northeast part and in Keewatin basalt at the southeast part. The vein consists of calcite which varies in width from a fraction of an inch to one or two inches, while in the northeast face it is a mere crack. A small stope about 60 feet long and 25 feet high was mined at the southwest part of the vein, along the Keewatin-Nipissing diabase contact.

The diabase contact occurs on the level below at the bottom of the shaft, a few feet west of the station.

TEMISKAMING

The Temiskaming Mining Company, Limited, has an authorized and issued capital of $2,500,000 in shares of the par value of $1.00. To November, 1920, when the company ceased operations, the mine had produced 11,721,433 ounces of silver, and had paid $2,159,156 in dividends. This large output was obtained from eight acres of ground. There are about nine miles of underground workings, including drifts, crosscuts, winzes, raises, and shafts.

The Temiskaming Mining Company owns half of the capital stock of the Blue Diamond Coal Company, Limited, the mines and plant of which are at Brule, in the Province of Alberta. The remaining half of the stock of the Blue Diamond Coal Company, Limited, is owned by the McIntyre Porcupine Mines, Limited.[1]

The general manager at the time the plant closed in November, 1920, Mr. Gordon F. Dickson, in discussing the reasons for the closing down of the Temiskaming, stated that the price of silver fell during the year 1920 to such a low level that profitable operation was not possible in view of the high cost of labour and supplies; these factors, combined with the shortage of power due to the dry season, caused the plant to cease operations. In regard to the finding of more silver ore, Mr. Dickson stated that the likelihood of discovering any quantity of high-grade ore in the old workings was small. He thought, however, there was scope for opening up a considerable tonnage of medium-grade ore which would show a profit with silver at 70 cents an ounce.[2]

---

[1] Report of the Temiskaming Mining Company, Limited, for the eighteen months ended June 30th, 1921.

[2] Ibid, page 12.

Structure

The structure of the rocks, and the relation of the veins to the rocks at the Temiskaming, is shown in the coloured cross-sections facing page 32. Take, for instance, the section marked D-D through the main shaft of the mine. It will be seen that the Nipissing diabase sill is shown intruding the Keewatin rocks, and that the sill has a thickness of about 1,000 feet. The Keewatin consists of what appear to be two lava flows of basalt, separated by a bed of finely banded chert and greywacké, known as "iron formation", but which in this description will be called the chert bed. It is 100 to 200 feet thick, dips about vertically, and strikes a little east of south. The basalt adjacent to the chert on the west is generally rusty, owing to the presence of iron pyrites which is partly weathered limonite. The vertical section shows the chert formation below the diabase sill, but its exact position there was not ascertained, as the 1,600-ft. level was not accessible; nor is it known to the writer whether the mine workings intersected the chert. The hanging wall and footwall of the diabase sill may have been displaced relatively to each other during the intrusion of the diabase, in which case the chert below the sill may be difficult to find. Its strike below the sill might be different from its strike above it, depending on the character of the movement between the footwall and hanging wall of the sill.

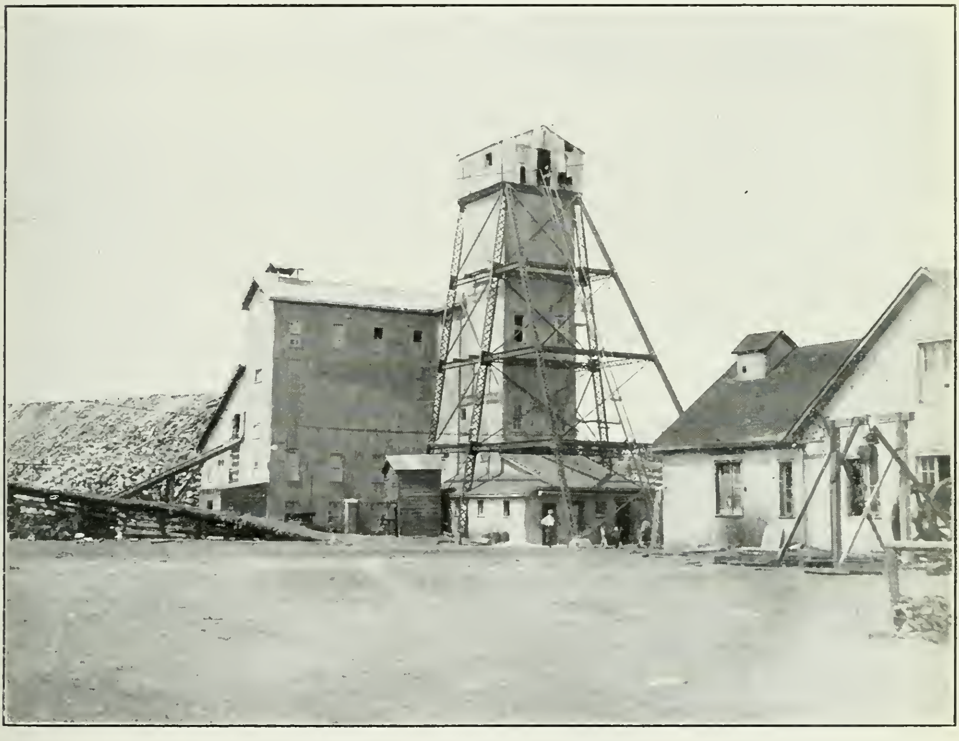


Fig. 28—Temiskaming shaft-house.

The position of the veins in relation to the top of the sill is shown in the sections. It will be noted that the veins in the diabase dip to the westward, about at right angles to the dip of the top of the sill. In fact, the veins appear to occur in joint planes in the diabase; these joint planes are about at right angles to the contact. As the veins emerge upwards from the top of the sill, they become vertical for a short distance above the contact and then dip steeply eastward.

Attention may be directed to what has the appearance of being a sharp fold in the Nipissing diabase sill, shown at the west side of the vertical sections facing page 32. It is doubtful, however, if this sharp irregularity in the sill was caused by folding. The writer could not find proof of folding. Rather would it appear that the sill was intruded through the Keewatin rocks in this irregular form. The occurrence, however, of the silver-bearing veins just to the east of this sharp irregularity may be pointed out. The question naturally arises: Will silver be found in commercial quantities below the sill under similar structural conditions?

Intruding the Keewatin rocks are many lamprophyre dikes and sills of Haileyburian age, several feet in width. The veins are, of course, younger than these dikes.

A dike of basalt, about a foot wide, has been found cn the 385-ft. and 499-ft. levels. It appears to be younger than the veins, although this is not definitely proven.

Veins

The vein-system of the Temiskaming and Beaver consists mainly of two parallel veins, 200 to 250 feet apart, striking a little east of north. The system has a length of approximately 2,400 feet. The Temiskaming owns the southern two-thirds and the Beaver the remaining part to the north. The entire system yielded 18,293,216 ounces of silver, of which quantity the Temiskaming has produced 11,681,900 ounces.

The Temiskaming-Beaver system is an isolated one, removed as it is almost a mile from the nearest productive vein, namely, No. 3 vein at the southeast corner of the Kerr Lake property. The productive part of the veins was terminated at the north end of the Beaver by a fault, to the north of which no silver has yet been found, although some of the veins, consisting of barren calcite, do extend north of the fault.

The ore at the Temiskaming occurs wholly at the top of the Nipissing diabase sill, both in the sill and in the overlying Keewatin, most of it having been mined from veins in the Keewatin. The ore bodies of the Keeley and Frontier mines in South Lorrain occupy similar structural positions. The writer was informed that more than three-quarters of the ore at the Temiskaming came from within about 125 to 150 feet of the contact. While most of the ore came from near the contact, it may be noted that one shoot of high-grade ore was mined 40 feet below the surface, and that mill-rock was obtained at the surface about the time the company ceased mining in the autumn of the year 1920. Reference to the richness of the ore along the contact is made in the annual report of the company for the year 1915.[1] The report states that along the contact, both above and below, the Temiskaming and Beaver have recovered their richest values.

As illustrating the richness of the ore at or near the upper contact of the Nipissing diabase sill, the shipments for the year 1910 may be referred to. The high-grade ore produced that year by hand-sorting amounted to 376 tons, the average assay value of which was 3,562 ounces. One 32-ton car assayed as much as 4,423 ounces of silver per ton. The major portion of these 376 tons came from the 396-ft. level. From the level below this, namely, the 499-ft., one car of 25 tons was shipped which contained a total of 202,806 ounces of silver, and netted $117,962. This car was shipped in the year 1912 and was the richest per ton car lot ever shipped from Cobalt up to that time, according to the company's statement.[1]

---

[1] Annual Report, Temiskaming Mining Company, for year 1915, p. 5.

While all of the silver was obtained from veins at the top of the diabase sill, it may be added that a vein was found below the sill on the 1,600-ft. level; it did not, however, produce silver.

The greatest depth below the surface from which the ore was mined was about 800 feet.[2]

Of the two main veins, referred to above, the westerly one is No. 19; its northward extension into the Beaver is known as No. 3 vein. The easterly vein is known as the No. 1 and No. 3; its northward extension into the Beaver is known as the No. 5 vein.

The coloured section, facing page 10, shows the stoped portions of veins Nos. 1 and 3 on the Temiskaming and vein No. 5 on the Beaver.

Vein No. 19 was first discovered on the Beaver, where it was known as vein No. 3. In view of the importance of this vein on both properties, we publish elsewhere in this report, on page 150, an account of its discovery, as written by Mr. F. L. Culver, president and general manager of the Beaver, and president and general manager of the Temiskaming at the time of the discovery of the vein.

The ore-shoots in some of the veins occur in such an irregular and erratic manner that it was impossible to accurately estimate the ore reserves from year to year. Mr. Norman R. Fisher, who was general manager until the year 1914, makes the following comments regarding the difficulty in estimating ore reserves.[3]

> Notwithstanding that I have been in close touch with this property since its infancy, thereby gaining a very intimate knowledge of the occurrence and intricacies of its ore bodies, still the estimation of its ore reserves is to me an enigma the solution of which I hesitated to approach.
>
> Though the various veins are exceptionally persistent both in depth and strike, they prove very erratic in values, so much so that it is practically impossible to gauge within reasonable limits one way or other the quantity of silver they contain.
>
> Likewise as regards the milling reserve I can but reiterate the opinion voiced in my last report as to the utter impossibility of doing this justice. Here the values are also irregular and the ore not only occurs as mineralized zones, traversed by rich narrow streaks, but as lenses and pockets of high-grade distributed throughout otherwise lean but strong calcite veins.

The productive parts of the Temiskaming vein-system extended into the Gans ground on the south, a distance of only about 250 feet. The Gans lot is owned by the Temiskaming and constitutes the south part of the Temiskaming property. Not much silver was discovered in the middle and south parts of the Gans. At one time, however, it looked as if important quantities of high-grade ore would be found in vein No. 506, but development work proved disappointing; it was stated that only in the neighbourhood of some 10,000 ounces of silver were recovered. This vein occurs in about the middle of the Gans lot, and about 150 feet west of the east boundary; it roughly parallels section line 500 on the 499-ft. level. Regarding the discovery of this vein, the following is quoted from the annual report of the company.[4]

> In the middle of April [1919] a pocket of high-grade ore was found at the 499-ft. level in 506 vein on the Gans property. Subsequent development disclosed other rich patches in this vein, but although, owing to their irregular occurrences, the tonnage obtained from this source has been comparatively small, there is encouragement for the belief that the development scheme now in progress in this southern area of the property may ultimately disclose more permanent enrichment in the veins.

---

[1] Sixth Annual Report, Temiskaming Mining Company, Limited, December 31st, 1912, p. 16.

[2] Eighth Annual Report, Temiskaming Mining Company, Limited, December 31st, 1914, p. 14.

[3] Fourth Annual Report, Temiskaming Mining Company, Limited, February 18th, 1911, p. 28.

[4] Annual Report, Temiskaming Mining Company, Limited, year ending December 31st, 1919, p. 10.

Copper

The occurrence of copper in the mine is of interest. The report of the company for the year ending December 31st, 1912, states that 16,037 pounds of copper were sold, for which $1,133 was received, this being the first instance in the history of Cobalt in which copper was produced in economic quantity.

Special Examinations

Towards the end of the time that the ore reserves of the Temiskaming began to play out, the company had four special examinations and reports made. These reports were made by Mr. R. J. Ennis, consulting engineer for the company, Mr. Balmer Neilly, Mr. Douglas Mutch, and Mr. A. R. Whitman, geologist.

The report by Mr. R. J. Ennis gives a first-class summary of the history of the mine from its beginning to the middle of the year 1918. The following is quoted from the report by Mr. Ennis, dated July 3rd, 1918.[1]

> During the last four months the mine has been carefully examined, plans and sections made of the workings and a geological examination made by Mr. A. R. Whitman, from all of which has been outlined a plan of exploration.
>
> The broken ore reserves were exhausted in the latter part of April and as only a few faces in the mine were producing ore, the concentrator was shut down and all machines were put on exploratory work.
>
> The mine started to ship silver in 1908 and for ten years has shown a varied production. The annual reports of the Company also show equally varying ore reserves, bringing out the fact that the ore shoots in the veins on the property are of most irregular occurrence.
>
> The operation of the mine may be divided into two periods. First, from the beginning of production in 1908 to the end of 1913, when Veins Nos. 1 to 16 were worked and reached their maximum production, yielding 142,818 tons of ore, from which 7,173,360 ounces of silver were recovered, or 50.2 ounces per ton, including both high-grade and mill-rock. To make this production possible 21,851 feet of development work was done, or one foot for every 328 ounces of silver obtained. In the second period, from 1914 to the end of 1917, Veins Nos. 19 to 21 were opened up and together with a small tonnage from the ends of Veins Nos. 1 and 16 produced 91,595 tons of ore yielding 3,664,559 ounces of silver or 40 ounces per ton of ore mined. Seventeen thousand six hundred and fifty-two feet of development work was performed in this period, or one foot for every 207½ ounces of silver obtained.
>
> All the productive veins on the property have been found in about eight acres of ground in the west half of the Temiskaming Lot. On the levels of the mine within this area above the diabase sill and on the 575-, 650- and 725-foot levels in the diabase 38,000 feet of crosscuts, drifts, raises and winzes have been driven. This work has thoroughly prospected the ground, leaving but little chances of finding any extensive ore bodies in this territory.
>
> From Mr. Whitman's report, printed herewith, it will be noted that the productive veins run north and south over a trough in the diabase sill and that a similar trough exists in the diabase in the Gans Lot. The veins on the Temiskaming and Beaver mines no doubt belong to the same system, which has been productive over a trough or basin in the diabase sill 1,300 feet wide, the southern arch being in the north end of the Gans Lot and the northern arch being four hundred feet in the Beaver Property. From this whole system has been produced to January 1st, 1918, approximately 433,000 tons of ore yielding about 16,000,000 ounces of silver. The trough in the Gans Lot is probably 900 feet wide, in which are favourable chances of finding a new vein-system containing high-grade ore-shoots. An exploratory programme has been laid out to thoroughly prospect the Gans Lot above the diabase sill and the Gans and Temiskaming Lots below the diabase sill on the 1,600-foot level. This programme will be completed in six months and in the meantime prospecting will be continued in the old vein system.

The trough referred to by Mr. Ennis is shown on the coloured section opposite page 10. This section is drawn parallel to veins Nos. 1 and 3 on the Temiskaming and No. 5 on the Beaver.

Regarding the reports of Mr. Balmer Neilly and Mr. Douglas Mutch, the following is quoted from a report to the shareholders by the mine manager, Mr. I. S. McReavy.[2]

---

[1] Special Report to Shareholders, Temiskaming Mining Company, Limited, 1918, pp. 4-5.

[2] Special Report to Shareholders, Temiskaming Mining Company, Limited, 1918, p. 5.

The operation of the mine was taken over by the present management on February 7th of the current year [1918] and, after thoroughly examining the mine and ore records, it was found that the estimate of ore reserves made by Mr. Balmer Neilly on August 7th, 1917, and by Mr. Douglas Mutch, on October 31st, 1917, were practically correct. From the date of Mr. Neilly's report to February 7th, 1918, 566,180 ounces of silver were produced, 2.8 per cent. more than the amount estimated. From the date of Mr. Mutch's report to February 7th, 1918, 304,444 ounces of silver were produced, 22.8 per cent. less than the amount estimated.

Mr. McReavy has, in the following table, summarized the operations of the company since its incorporation to December 31st, 1917.[1]

	Progress	Shipping production		Positive ore reserves		Ounces per ft. of development (on ore hoisted)
	feet	tons	ounces	tons	ounces	
9 months to 31st Jan., 1908.	......	....	452,229	....	....	....
12 months to 31st Jan., 1909	......	....	976,027	....	....	....
Previous to 31st Jan., 1909	3,110	....	....	....	....	....
31st Jan., 1909, to 31st Jan., 1910	3,082	794.298	682,861	74,220	3,298,000	380.2
31st Jan., 1910, to 31st Dec., 1910	3,042	1,029.210	1,872,708	118,681	4,805,532	607.2
1st Jan., 1911, to 31st Dec., 1911	3,586	909.000	1,213,754	Not estimated		296.1
1st Jan., 1912, to 31st Dec., 1912	4,645	1,004.200	1,242,243	Not estimated		227.8
1st Jan., 1913, to 31st Dec., 1913	4,397	572.100	739,726	Not estimated		193.9
1st Jan., 1914, to 31st Dec., 1914	2,791	....	278,961	Not estimated		100.0
1st Jan., 1915, to 31st Dec., 1915	4,763	....	1,456,894	Not estimated		305.9
1st Jan., 1916, to 31st Dec., 1916	5,243	....	963,848	Not estimated		183.8
1st Jan., 1917, to 31st Dec., 1917	4,896	....	958,670	Not estimated		195.8
	39,555		10,837,921			

	Cost per oz. (on shipping production)	Mar- price ket per oz.	Profit per oz.	Ore hoisted, cost per ton	Ore milled, cost per ton	Net profit
	$	$	$	$	$	$
9 months to 31st Jan., 1908	......	......	....	....	....	....
12 months to 31st Jan., 1909	......	......	....	....	....	....
Previous to 31st Jan., 1909	......	......	....	....	....	....
31st Jan., 1909, to 31st Jan., 1910	0.349	0.520	0.171	13,063	....	75,178.30
31st Jan., 1910, to 31st Dec., 1910	.177	.540	.363	17,917	15,250	691,713.88
1st Jan., 1911, to 31st Dec., 1911	.311	.540	.229	15,220	10,863	271,423.09
1st Jan., 1912, to 31st Dec., 1912	.292	.606	.314	11,525	9,049	413,150.38
1st Jan., 1913, to 31st Dec., 1913	.434	.598	.164	9,936	9,932	117,574.02
1st Jan., 1914, to 31st Dec., 1914	.903	.490	loss .413	unavailable	unavailable	81,422.35 loss
1st Jan., 1915, to 31st Dec., 1915	.198	.497	.299	"	10,710	443,864.17
1st Jan., 1916, to 31st Dec., 1916	.402	.657	.255	"	11,770	321,666.87
1st Jan., 1917, to 31st Dec., 1917	.373	.819	.446	10,683	11,235	518,556.92

Extracts from Mr. A. R. Whitman's report[2] are given below:—

The diabase sill is the formation of chief interest, because it was the source of the silver ores of the district. They emanated from it, in a state of solution, and were deposited in the form of mineral, in fractures adjacent to the margins of the mother formation. In the Keewatin, and in the diabase itself, commercial ore bodies occur only within 350 feet of the margins of the sill.

---

[1] Special Report to Shareholders, Temiskaming Mining Company, Limited, 1918, p. 7.

[2] Special Report to Shareholders, Temiskaming Mining Company, Limited, 1918, pp. 12, 13.

The configuration of this sheet of igneous rock is significant, and is due to the fact that it was injected into its present position in a molten condition. The wedge-like advancing edge of the molten mass worked its way along a nearly horizontal line of fracturing, being compelled to pursue, frequently, more or less wavy courses. As it advanced it lifted up the great mass of overlying Keewatin formation which at that time extended above the horizon of the present surface After the entire body of molten diabase had come into place, and had consolidated into cold rock, certain compressive forces in the earth's crust became active to the extent of slowly bending the sill into folds, which tended to form along the undulations which already existed in its configuration. That is, the undulations were accentuated by the folding.

These processes developed fractures which bore certain relations to the sides of the folds; and those fractures afterwards became filled with the ore minerals, which diffused into them from the sill, making the present veins.

It is by determining the configuration of the sill, and the localities and directions of folds and fractures, that it is possible to know where conditions were favourable for the deposition of good veins.

It has been found that where there has been folding, flatly inclined joints, faults and shear-zones have been produced parallel to the sides of the folds. And it has also been found that they have served as feeders of mineral to the veins; so that the richness of the ore bodies is, to a considerable extent, proportional to this flat shearing, and to the acuteness with which the troughs and arches have been compressed. Thus, the richest veins should be found on the sides of, or spanning such folds, where there has been much shearing in the adjacent diabase.

It is also important to bear in mind that the undulations in the lower margin of the sill must correspond to those in the upper margin, since the two are parallel. And an arch of Keewatin under the sill may be as favourable a place for ore as a trough in the upper margin.

Cases.—The development outlined on the 1,600-ft. level is a case in point. The east crosscut is designed to diagonally cross the axis of an arch in the Keewatin under the sill. It is expected that veins would be found crossing the arch, and that the arch would be found to have been compressed to such an extent that shearing would have been developed on its sides, in the sill, adequate to have produced commercial ore bodies in the veins.

Virtually the entire production of the Temiskaming mine has come from fractures which crossed a trough in the upper margin of the sill. This trough pitches eastward, and its axis is concave upward, the good veins occurring only where its slope lies between 10 and 25 degrees. The sides are well sheared on the margin of, and within the sill, thus making favourable conditions for the supply of mineral to the veins. It is important to note that although the shearing continues into the interior of the sill, it is only near the margins that it affects their richness. This is because the individual fractures are not persistent, and mineral drained from the interior by them cannot be contributed directly to a common seat of deposition, but must find its way to the margin, where the shearing is continuous and more concentrated. Thus it can be only from the margin of the sill, or from the marginal region, that mineral could have been fed in commercial quantities to any given vein. The only exception to this would be a very strong and persistent shear-zone within the sill. But such a thing is not known to exist in this property, the shear-zone found in the shaft just below the 1,400-foot horizon not being of sufficient importance to fall in this class, nor to be of any other significance.

The Discovery of the Temiskaming Mine

By Charles A. Richardson

For the following very interesting account of the discovery of the Temiskaming mine, the Ontario Department of Mines is indebted to Mr. Charles A. Richardson, one of the pioneers at Cobalt. The plan of the 80-ft. level, referred to by Mr. Richardson, is not shown on the Beaver and Temiskaming Sheet, No. 31a-1.

Early in the year 1905 a syndicate was formed by Mr. R. A. Cartwright, Mr. J. L. Wheeler, and the writer, for the purpose of exploring for or otherwise securing ground of possible merit in the Cobalt area. Later we associated Mr. B. E. Cartwright with us by dividing our original syndicate shares into four instead of three parts; and this proved fortunate for us, as it was largely through Mr. B. E. Cartwright's efforts that the large expenditures, that were entailed in bringing this property to a producing state, were arranged for.

A claim of twenty acres, which later became the north half of the Temiskaming mine, was staked by Alex. Daigle, at that time an employee of the Vendome Hotel at Haileybury, under an arrangement with the writer whereby I secured a one-half interest for doing the statutory assessment work on the ground with an option on the one-half interest which he still owned. These options were taken by me for the benefit of myself and associates, and I commenced prospecting work on this claim during the latter part of April, 1906. The first stripping and trenching was done near the central part of the claim, which consisted of twenty acres, at a point about five chains from its eastern boundary and on the 18th of May we had uncovered some small fractures showing cobalt bloom.

At that period of the camp's development this occurrence of cobalt bloom was considered of more importance as an indication of probable enrichment than was later the case, and as at that time it was necessary to have inspection for discovery by the Ontario Bureau of Mines' representative in order to obtain title to the claim as mining property, I immediately arranged with Mr. E. T. Corkill, at that time mining inspector, for an examination for "discovery." Mr. Corkill accompanied me to the property on the 19th May, and examined the occurrence above referred to and then spent some time with me in a general examination of the claim. At a point on or near the south line of the claim, about where No. 2 shaft was afterwards located, we had built a small log hut and to the west of this there was a "draw" or section of low ground with a general north-south strike. Mr. Corkill expressed the opinion that this probably indicated a line of weakness and suggested the advisability of doing some trenching at this point. He and I put in the stakes for this work and the men started at once. I have always felt that Mr. Corkill's suggestion at that time was primarily responsible for the discovery that led to this property reaching its ultimate success.

That afternoon, after a very small amount of trenching work, the outcrop of what afterwards was known as No. 1 vein was uncovered and consisted of over twelve inches of smaltite and niccolite, afterwards proving on assay to contain little or no silver. When this discovery was reported to me late that evening at Cobalt, I immediately proceeded to the property for the purpose of staking the ground to the south as this discovery was on our south line with a strike approximately northeastward, which would consequently carry the vein into the ground to the south.

On my arrival I found that the claim to the south had been staked by a Mr. Gans on our discovery, his "discovery" post being in our trench and on the vein uncovered by our men. I accordingly staked the claim on the ground that as the discovery had been made by our employees it could not also be a valid "discovery" for one who had no part in the operation. This resulted in litigation as to the title to this additional claim of 20 acres, afterwards known as the "Gans" claim, and necessitated a restaking on our part. Eventually this claim became and now is a part of the Temiskaming mine.

We started a shaft, No. 2, on this vein and in sinking found that the character of the vein matter changed from massive smaltite and niccolite to calcite carrying little or no mineralization. This condition persisted to a depth of 80 feet at which point we started a drift north. There was no change until at a point about 90 feet north of the shaft we encountered a body of very rich ore, a few "rounds" out of which produced about twenty tons and realized about ninety thousand dollars. Encountering this enrichment at this depth was a most fortuitous circumstance, as very few if any of the veins afterwards developed on the property "apexed" as high as this above the diabase sill.

From this point the history of the property is too well known to require comment further than is covered by Mr. Fisher in his report to you.

I should like to add that I consider that the experience of this property, which is now being duplicated in the South Lorrain area, shows that, given proper geological and structural conditions, even in the absence of surface values, there are many opportunities still existing of developing properties of major importance in the diabase-Keewatin and diabase-sedimentary contact in the Cobalt area.

The Early History of the Temiskaming Mine

By Norman R. Fisher

Mr. Norman R. Fisher was general manager of the Temiskaming mine until the spring of 1914, and he was consequently familiar with the earlier development of the property. The writer asked Mr. Fisher to give the Ontario Department of Mines an outline of the early history and a description of the ore bodies which were mined up to that time. The Department is much indebted to Mr. Fisher for the following report which is dated January 12th, 1923. The numbering of the veins in the early days does not appear to quite agree with the numbering of the veins as shown on the Department's Beaver-Temiskaming sheet No. 31a-1; nor is the 80-ft. level shown on this sheet.

Though it was not until May, 1907, that silver in payable quantity was discovered at what is now known as the Temiskaming mine, its birth may reasonably be said to have taken place in the year 1906, with the discovery on the surface, during the summer of that year, of two strong calcite veins well bespattered with cobalt bloom and showing at points considerable smaltite, but containing little or no silver either in combined or free form.

Both these veins occurred in the Keewatin formation, which was at the time little favoured by experts for the occurrence of silver, and as a consequence the property might still have remained a mere prospect to this day but for the fact about this time it came under the control of that forceful pioneer of the northern Ontario mining field, Mr. B. E. Cartwright, who in after years took so prominent a part in and did so much towards the development of that field generally. It was he and his associates who, contrary to all expert advice, decided to prospect them at depth, and by the fall of 1906 had sinking on them both well under way.

At a depth of about 40 feet the work on the more westerly of these two veins, which some eight or nine years later proved to be such a bonanza at depth, was abandoned, not altogether because it was the less promising of the two at the time, but rather because of its being in low ground and so more expensive to explore, and thenceforth all energies were concentrated on the exploration of vein No. 1.

At the point where sinking was commenced on the latter, the vein was some ten inches wide of solid smaltite, with little or no silver content, but this very soon gave way at depth to very barren looking, unmineralized calcite and so continued until it eventually dipped from the shaft at a depth of about 50 feet.

Though lack of courage to proceed farther under such unpromising conditions might in those days have very well been excused, these resolute pioneers decided to keep on with their sinking, and to investigate the vein at still greater depth; and with this end in view eventually ran a crosscut to it some 80 feet below the collar of the shaft.

Where intersected the vein was still found to be a very strong one, some 12 inches wide, but unfortunately still entirely composed of barren calcite, with not even a sign of smaltite or any of its kindred metals in it to encourage farther exploration. Nevertheless, the owners remained steadfast in their resolve to locate the silver which they were still confident existed there, and forthwith decided to further prospect the vein by drifting upon it both ways at this level.

For some time very discouraging results obtained in this work. Nothing was encountered to indicate the near presence of silver. The vein continued both ways as barren-looking calcite, physically weakening towards the south, but gaining in strength towards the north until on May 17th, 1907, after drifting upon it for about 90 feet in the latter direction the miners, upon returning to the face after shooting a round of holes, were astonished to find some 15 inches wide of solid metal glistening before them with native silver sticking out all over it.

The next day, May 18th, is probably still very vivid in the memory of many of the old-timers of the north country because of the great excitement that was created when a large block of this ore was conveyed to Cobalt and publicly displayed to the great wonderment of the crowds who sought to view it, because its discovery under such apparently disadvantageous geological conditions had all along been so little expected.

This rich ore continued in the drift more or less constant in width and values for a length of about 30 feet, when it gave way entirely to barren calcite as suddenly and cleanly as it had come in, and it continued as such until it was decided to stop farther drifting upon it to permit of the ore shoot being mined for an early shipment.

Unfortunately the back stoping on this was not productive of much ore as it was soon discovered that the ore shoot had been encountered very near its apex, even at its highest point only carrying up some 15 or 20 feet above the back of the drift where it again gave way entirely to barren calcite.

Directly above this point the surface was considerably lower than around the shaft, and taking this into consideration I later figured that the top of this ore was about 40 feet from the surface.

After mining out all the ore to be found in this stope, the ore shoot was attacked by underhand stoping, and this work had reached a depth of some 36 feet from the bottom of the drift before the extraction of further ore was for the time being abandoned to permit of the shaft being sunk deeper so that the ore body could be more conveniently mined and its continuance to a greater depth established.

So far the work done upon it showed the ore shoot to be carrying to depth not only very regularly in length but unusually strong in width and constant in value, being in places as much as 37 inches wide of ore, the richness of which may be gauged from the fact that the initial shipment of 52,366 pounds made in May, 1907, gave a return of 123,786 ounces of silver, whilst a further shipment of 82,452 pounds made in August of that year gave a return of 185,178 ounces.

Up to this stage the exploitation of the property had been carried on with very primitive appliances and equipment. This was now replaced by more up-to-date steam-power equipment, and the sinking of the shaft to a farther depth of 100 feet was commenced.

Upon the completion of this a crosscut was run at a depth of about 173 feet to again intersect the vein, and after this had been done the extension of the ore shoot to this level was eventually picked up in it, again as strong and rich as when it had been left behind in the bottom of the winze above.

As soon as possible preparations were made to overhand stope the ore body from this level, and whilst this was going on prospecting for other ore bodies was also carried out.

The first discovery to be made in this search was of a vein some 2 or 3 inches wide, subsequently known as No. 4, which was encountered striking a few degrees north of east some few feet to the north of the ore shoot in No. 1 vein if not actually coinciding with its northern extremity.

Though carrying pay ore this vein was on the whole not nearly so rich as No. 1, being much more irregular in its silver content, and even at that time was noticed to be very different in certain of its physical characteristics, especially in that it occurred very free from the country rock enclosing it whilst No. 1 vein was always found to occur in a more or less frozen condition.

It disappeared towards the west as a mere knife blade crack, so was followed towards the east, and some 70 feet distant No. 2 vein, which together with its subsidiaries, subsequently proved to be probably the greatest producer of the property, was encountered. Striking in a north and south direction this vein was later found to traverse the full length of the property, running more or less parallel to No. 1 vein, and to contain not only well defined and regular chimneys and shoots of ore, but also numerous lenses occurring sporadically throughout it and varying considerably both in extent and richness.

Whilst these lenses had no apparent relationship to each other or any particular geological feature, the chimneys and shoots were plainly influenced in their occurrence by certain factors, the chimneys, which were more or less vertical and in places up to 4 feet wide of over 5,000-ounce ore, being intimately related to a system of cross-fissuring, whilst the horizontal shoots were undoubtedly governed in their occurrence by the Keewatin-diabase contact conditions.

The influence of this east and west system of fissuring on the occurrence of silver in the north and south systems was first noticed at the intersection of the east and west No. 4 vein or fissure with the north and south No. 2 vein, at which point rich ore was found to occur in the latter at the north of the intersection, whilst only barren calcite occurred to the south of it.

The vein was richest, too, at and near this intersection, gradually dwindling to barrenness towards the north as No. 4 vein or fissure was left behind, and thereafter continued as more or less barren calcite until another of these east and west fissures, merely a knife blade in width this time, was encountered. Here ore again came in with as remarkable suddenness and distinctness, only to once more dwindle in value towards the north as this cross-fissuring was also left behind.

Other such shoots or chimneys of ore were later found at similar intersections throughout the mine, and these being not only very persistent in depth but unusually regular in their width and values throughout, really proved to be the main source of production from this property during its active existence. It is significant, however, that though these ore-shoots carried down through the full depth of the Keewatin more or less regular both in length and width and with only an occasional lapse in values, they were never known to pass through the contact into the diabase sill below, though the vein itself, usually as white barren calcite and sometimes as pink calcite, invariably did.

In these veins, however, other ore shoots of the contact variety and apparently influenced in their deposition by the Keewatin-diabase contact were found in both formations. They generally occurred a few feet to one side or the other of the contact, with their longer axes paralleling it, and varied considerably in extent, the largest of them measuring about 80 feet long by about 40 to 50 feet deep of continuous ore, and wholly in the diabase.

These horizontal shoots and the lenses could only be located by intensive exploration at all levels, but the vertical shoots or chimneys of ore once located at any level were always easy to pick up again at any other level because of their intimate relationship to the east and west cross-fissuring before mentioned.

The close connection between this cross-fissuring and the existence of the chief ore bodies of the property was, in fact, very obvious almost from the beginning. As a result they were, during the seven years of my régime at any rate, looked upon and known about the mine as the feeders of the north and south vein-systems, and the exploration and development of the property was carried out with this feature in mind, accompanied, it may be added, with most satisfactory results.

Of the two veins originally discovered on the surface of this property and described at the beginning of this article, I have so far given the history of only vein No. 1, but it is also of interest to note that the other, upon which the 40-foot prospect shaft was sunk in the earliest stage of the property's development, only to be then temporarily abandoned for the certain good reasons already given, later proved to be just as important a producer, if not the greater of the two.

This vein was first investigated underground from a crosscut at the 173-foot level, but where intersected at this horizon appeared to be of very little importance. It was, however, later crosscut to at the 270-foot level and intersected almost directly below where it was first investigated by the prospect shaft at the surface, and here found to be of considerable promise, containing, it is true, an inappreciable quantity of silver, but considerable smaltite and niccolite, particularly the latter, up to 9 inches wide Indeed, so ripe-looking and promising did the vein appear to be at this point that it was given particular notice in the annual report of that year, and the prognostication was ventured that an ore shoot would sooner or later be picked up in it. It was with every expectation of this that two crosscuts were actually being run to it from the 499-foot level in the spring of 1914, when the writer retired from the general management of the property.

I have since learned that these crosscuts were later extended to tap this vein and actually encountered extremely rich ores where they intersected it, but owing to my departure I am not sufficiently conversant with the extent or richness of this ore body nor of the exact conditions under which it was found to be able now to give any authentic information regarding the same.

One other point, it is perhaps interesting to note respecting the occurrence of the ore bodies of this property, is that in the passage towards the silver the sequence in the occurrence of the vein matter was usually found to be the same at all points whether near the surface or deep underground.

Except of course where silver was encountered direct, as at the intersection of the above-mentioned cross-fissuring, the usual order was, first, smaltite in varying quantity, then, barren calcite, and when niccolite began to come, silver was always expected to appear in the next round or two of shots and usually did when this condition arose within the silver-bearing portion of the property.

The silver encountered would of course vary considerably in extent and would sometimes be associated with a predominance of niccolite, or one of its allied minerals, but usually these would soon give way to a predominance of smaltite.

In other words, whilst smaltite was usually the forerunner of the occurrence of silver, and was also generally the chief mineral intimately associated with the main mass of it, niccolite or one of its allied minerals generally predominated on the fringe of its occurrence, and when encountered in a vein existing under otherwise favourable conditions for the occurrence of silver, was always looked upon as an almost sure indicator of the near presence of silver.

Description of Temiskaming Mine Workings

The following is a brief description of the various levels of the Temiskaming mine, commencing with the lowest.

In mapping the contact between the Keewatin and the Nipissing diabase, the plans published by the company in the special report to the shareholders in 1918 have been of assistance. The contacts on the Department's maps agree, approximately, with those on the company's maps. The company furnished the writer with plans showing the location of the veins on the various levels.

1,600-ft. Level.—This level was full of water at the time of our examination, and was consequently inaccessible. The information shown on the plan was obtained from the special report in 1918 of the Temiskaming Mining Company, and partly from a geological plan furnished by Mr. Wm. Cooper, mine superintendent. It is reported that a non-productive vein was discovered striking north and south. The vein was said to occur in a fault which showed a few inches of fault breccia. The vein material in the fault was said to occur sparingly and irregularly in the fault. It has been followed by a drift for about 850 feet, and appears to be the same vein in which the Beaver is reported to have found 40,000 or 50,000 ounces of silver on the 1,600-ft. level.

The workings are in Nipissing diabase and in the Keewatin series.

About 150 feet above the 1,600-ft. level, in the shaft, there is reported to be a shear zone.[1]

1,130-ft. Level.—A station has been cut at this level; the rock is Nipissing diabase.

830-ft. Level.—This level has only 150 feet of workings, all in Nipissing diabase. The coloured section opposite page 10 shows a raise from this level to the level above, namely, the 749-ft.

749-ft. Level.—The veins on this level consist mostly of white calcite, and subordinately of pink calcite. They all dip steeply to the westward, and are in the Nipissing diabase. The veins are smaller on this level than the veins on the levels above.

649-ft. Level.—This level is also all in Nipissing diabase, the most easterly crosscut, however, shows the diabase gradually becoming finer in grain, suggesting that the Keewatin rocks are not far east of the face of the crosscut. The veins also dip to the west, as in the level below, following joint planes in the diabase. In the long crosscut westward of the shaft, there is a flat fault showing fault breccia and gouge an inch or two in width.

573-ft. Level.—This level shows how the veins pass from the Nipissing diabase into the Keewatin rocks. There is a long crosscut extending over 800 feet east of the shaft to the east boundary of the property. This crosscut went through the chert formation and showed it to have a width of about 175 feet. The Keewatin rocks immediately west of the chert formation are impregnated with iron pyrites for a width of 100 feet, and the walls of the crosscut in this iron-pyrites zone are rusty, owing to the decomposition of the sulphide. In the same crosscut east of the chert formation, there is a lamprophyre dike dipping 18° to the northeast. As on the levels below, so also on this level the veins in the Nipissing diabase dip steeply westward.

---

[1] Special Report to Shareholders, Temiskaming Mining Company, Limited, 1918.

499-ft. Level.—This is the most extensive level in the mine, the workings extending from the north boundary almost to the south, a distance of nearly 1,800 feet.

Vein No. 19, at the northwest end of the property, was an important producer. It is the southward extension of No. 3 on the Beaver. The vein was followed for over 500 feet south of the Beaver boundary, but the ore-shoot continued for only about 190 feet south of the boundary. It is stated that the silver content of the vein suddenly disappeared, although the calcite vein continued to the south. The writer is not able to account for the sudden disappearance of this ore-shoot.

Vein No. 20 is a strong pink calcite vein; it occurs in a fault which has about a foot of fault breccia.

At the northeast end of the mine, veins No. 6 and No. 3 are in chert. Some low-grade mill-rock occurred in the chert.

Vein No. 506 is in the southeast part of the Gans. It about parallels the north and south co-ordinate line 500, and lies between the east and west co-ordinate lines 1,100 and 1,500. The company did not apparently keep a record of the silver output of the vein, but the writer was informed it produced about 10,000 ounces of silver. The vein gave promise of an important output, but its exploration proved disappointing. The vein consists mostly of white calcite up to eight inches wide, possibly averaging three or four inches. In one place niccolite makes up half of the vein. In the stope a narrow dike of pink feldspar-porphyry cuts the Keewatin. The dike has been faulted about six inches. The vein cuts about at right angles across the fault (Fig. 29), but the vein is not faulted. This appears to be a clear case in which it is proved that a vein is younger than a fault.

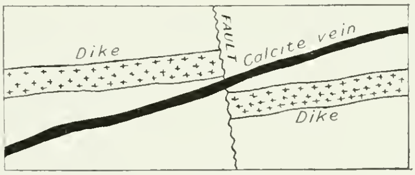


Fig. 29—Sketch showing relation between feldspar-porphyry dike, fault, and calcite vein; 499-ft. level, Temiskaming mine. The vein is two to three inches wide, and is clearly younger than the dike or fault.

At the southeast corner of the workings, a vein has been followed for about 350 feet, and a little stoping has been done. The vein where examined consisted of calcite two or three inches wide. Near the vein some narrow granite dikes cut the Keewatin. These dikes no doubt come from the granite mass a short distance to the east.

385-ft. Level.—This level is almost wholly in Keewatin rocks, although the diabase has been intersected in three short crosscuts at the west side of the workings. Minor faulting, indicated by gouge and fault breccia a few inches wide, has taken place at or near the contact of the Keewatin and diabase. The crosscut at the northeast corner of the level has intersected the chert formation and shows it to have a width of about 200 feet. About the central part of the level there is a fresh basalt dike, 12 or 15 inches wide, cutting the Keewatin rocks and dipping about 70° to the southwest; the relationship of the dike to the veins was not definitely determined, but the dike appeared to be younger than the veins. In raise No. 402, about 90 feet above the level, the dike appears to cut a calcite vein.

350-ft. Level.—This level is not connected with the main shaft; it is reached by a raise from the 270-ft. level. Very little work, comparatively speaking, has been done.

270-ft. Level.—The workings are all in Keewatin cut by lamprophyre dikes of Haileyburian age. The chert bed was not intersected, but its probable position is shown on the plan. Vein No. 17 occurs in a fault, showing fault breccia four or five inches wide, and gouge fractions of an inch wide.

226-ft. Level.—Also all in Keewatin rock; the probable position of the chert bed is indicated on the plan.

173-ft. Level.—The level is in Keewatin; the long eastward crosscut intersects the chert bed for about 75 feet. The basalt west of the chert is sparingly impregnated with iron pyrites for about 150 feet.

90-ft. Level.—This level is not shown on the plans. At the time of our examination of the level, during August 1920, the stope was about 350 feet long and the ore was reported to run from 6 to 22 ounces of silver per ton. The stope was broken through to the surface in one place. In places there are two quartz veins, more or less parallel.

These quartz veins appear to have been opened up and fractured, allowing the calcite to be introduced later into them. Fragments of quartz appear in the calcite. In places the quartz is banded and the calcite cuts across the banding of the quartz; in other places there is no quartz in the vein. On the west wall of the stope, a few feet west of the vein-system, there is gouge and fault breccia a few inches wide; on the gouge there are pronounced scratches dipping 20° to 30° to the south.

TRETHEWEY (CONIAGAS)

The Trethewey was purchased by the Coniagas Mines, Limited, in January, 1920, for $100,000. Prior to that time the property produced 6,761,581 ounces of silver and paid $1,211,999 in dividends.

In respect to the veins, the property may be divided into two parts, one at the northeast corner and one at the southeast. The latter is the more important, the vein-system there being the westward extension of the Meyer system on the Nipissing and the northward extension of certain veins on the Coniagas. The "main" vein on the Trethewey is the westward extension of the Meyer vein on the Nipissing. The productive area at the southeast corner of the Trethewey is only about eight acres in extent. The veins at the northeast corner of the claim are southward extensions of veins on the Hudson Bay; they are worked from No. 4 shaft.

The stope section of the main vein is shown on the vertical section on page 9.

The largest stopes on the property are on the "main" vein, and on the extension into the Trethewey, of one of the Coniagas veins, No. 2. These stopes are thirty or forty feet wide in places.

As on the Coniagas, Buffalo, and Townsite, so also on the Trethewey there is a fault which is roughly parallel to the contact between the Keewatin and the Cobalt series. On the first level the fault is found entirely in the Cobalt series, but in the lower part of the mine the dip of the fault becomes steeper, and it passes into the Keewatin series. It has not been traced quite down to the third level, but was found in a sub-level above the second level, and on the second level. This fault has been called the Trethewey fault on the plan of the first level, while on the sub-level referred to, it is called the "reverse" fault. It is probably continuous with the Coniagas fault. On this sub-level the Keewatin has been thrust on top of the Cobalt series, proving that the fault is a reverse one, the displacement of which is at least 15 feet (section facing page 8).

The sediments of the Cobalt series on the Trethewey are not as thick as they are on the Coniagas, nor does the bed of slate-like greywacké, which is well developed on the 150-ft. level of the Coniagas, extend into the Trethewey.

Trethewey Mine Workings

Third Level.—(No. 2 shaft, elevation above sea level 900 feet.) The third level is a small one at the southeast corner of the mine with some 700 feet of workings. About a third of the workings are in the Keewatin series, the remainder in conglomerate and greywacké of the Cobalt series. The contact between the Keewatin and Cobalt series may be seen in a crosscut; the contact is sharp and well defined.

There is no sign of the Trethewey fault to be seen on this level, probably because the fault has passed into the Keewatin below the level. The workings do not appear to have extended far enough to the northwest to have encountered it.

Second Level.—(No. 2 shaft, elevation above sea level 945 feet.) The second level at the southeast corner of the property has encountered the Keewatin series in four places. In one of these places a lamprophyre dike cuts the Keewatin; a granite boulder of the Cobalt series about three feet wide was found resting directly on the lamprophyre dike. Evidently the contact between the conglomerate and the old basement is sharply defined here. In No. 6 shaft the contact between the Keewatin and the conglomerate of the Cobalt series occurs about 15 feet above the second level. The Keewatin here consists of a fine-grained grey slate resting in almost vertical attitude. This bed of Keewatin slate is exposed on the surface along the shores of the deep bay of Sasaginaga lake, westward from No. 6 shaft.

Sub-levels between the First and Second Levels.—The sub-levels form a complex group of workings which were somewhat difficult to map in a satisfactory manner. A composite plan of the sub-levels will be found on the Trethewey sheet, together with separate geological plans of each sub-level. On the sub-level, the elevation of which is 970 feet, the plan shows a "reverse" fault. This is probably the Trethewey fault; it is a reverse fault with a displacement of at least 15 feet. The Keewatin has been thrust on top of the Cobalt series.

First Level.—(No. 2 shaft, elevation above sea level 1,021 feet.) The Trethewey fault has been traced for about 700 feet. It may be studied in daylight in the open cut at No. 1 shaft. The fault has a fault breccia two or three feet wide in the first crosscut south of No. 5 shaft. In the open cut referred to the fault splits, the upper part following the bedding and the lower part cutting across the bedding.

No. 6 shaft, about the middle of the property, was sunk on a vertical "mud seam", or fault, with fault breccia and gouge one-half or three-quarters of an inch wide. In one or two places it is two inches wide. The fault on the first level has been drifted on for about 250 feet. No. 6 shaft was sunk on this fault to the second level where a pink calcite vein, an inch or two wide, was found in the fault.

At the northeast corner of the property certain veins are worked from No. 4 shaft. These veins were not of great importance and the stopes were all small.

HUDSON BAY

The Hudson Bay Mines, Limited, has a capital of $3,500,000 in shares of a par value of $5.00 each. Of this, $3,200,000 have been issued. The property north of the Trethewey mine has produced 6,405,938 ounces of silver and has paid $778,909 in dividends to the end of the year 1922.

The productive part consists of a small area in the southeast corner of the property.

There are two important veins, namely, No. 2 and No. 1, the locations of which are shown on the fourth level. The plans do not give the numbers on the higher levels. The No. 1 vein strikes a little north of west and occurs immediately south of the main shaft. No. 2 vein passes into the Nipissing and is known as No. 64 on that property.

Other veins occur, but the two referred to are the most important producers of silver.

No. 1 vein has been explored in the Keewatin to a depth of over a hundred feet, and it has still a width of one to eight inches of barren calcite. An interesting feature regarding this vein, where it occurs in the Keewatin, is that it follows the dip and strike of a bed of Keewatin chert and slate commonly called "iron formation." Evidently this fundamental structure in the Keewatin formation constituted a line of weakness along which the vein fracture formed, and these fractures extended upwards into the Cobalt series. The overlying sediments of the Cobalt series may have had little or nothing to do with the guidance of the fracture. Certain veins in the Foster, Buffalo, and other mines were also found to follow the strike and dip of similar almost vertical beds of Keewatin chert or slate, known as "iron formation."

On the surface of the Hudson Bay property the "iron formation" and lava flows of the Keewatin series may be worked out. The Keewatin consists of three or four beds of sediments interbedded with basaltic lava flows. The sediments strike a little south of east and dip steeply to the southward. They consist of chert and slate. It is one of these beds of sediments which the No. 1 vein follows where it has been explored in the Keewatin.

It was stated by the management that veins Nos. 1 and 2 were the only ones that produced important quantities of mill-rock. The stopes of these veins are wide, in places 15 to 40 feet. The other veins yielded mill-rock for only two or three feet on each side of the veins.

There are three almost vertical faults, striking southeastward and dipping steeply to the southwestward. The best known one is No. 64. The others, known as Z and Y, are north of No. 64, and they appear gradually to join No. 64 on the Nipissing. Faults Z and Y are shown on the third level of the Hudson Bay. Comparatively little silver occurs to the north of these faults. The question arises as to what influence the faults had on the deposition of the silver. It is possible that the faults acted as a barrier or dam to the silver solutions, preventing the latter from depositing silver north of the faults. This idea, however, is merely a suggestion; but whatever may have been the cause, the fact remains that little silver has been found to the north of these faults, on the Hudson Bay, Nipissing, Chambers-Ferland, O'Brien, or Violet. It must be admitted, however, that the rocks north of the fault have not been intensively prospected by underground workings.

No. 2 vein on the fourth level occurs in fault No. 64. This fault is evidently older than the vein. The other two faults, Z and Y, contain calcite in places.

In addition to the three faults mentioned, there is another fault dipping southeastward which follows in a general way the contact between the Keewatin and Cobalt series. This fault probably corresponds to the Trethewey and Coniagas fault which is known as the "contact" fault. It occurs also on the Buffalo, Townsite, and City properties.

Below will be found a brief description of the various levels of the Hudson Bay, beginning with the lowest.

Hudson Bay Mine Workings

Fifth Level.—(Elevation above sea level 797 feet.) The fifth level is reached by means of a winze from the fourth. This winze is located at the southeast corner of the property on vein No. 2, about 15 feet from the Nipissing boundary. The level and winze were full of water at the time of examination, but, judging from the dip of the Keewatin floor, it is probable that the Keewatin occurs some 10 feet or more below the fourth level. Thus, the fifth level is probably entirely in Keewatin.

Fourth Level.—(Elevation above sea level 847 feet.) No. 1 vein has been explored in the Keewatin on this level in the drift. It is a strong vein from one to six or eight inches wide, and it has been stoped in places. The interesting thing about this vein in the Keewatin is that it follows a bed of chert and slate known as Keewatin "iron formation", the bed being in an almost vertical position. On levels above, this vein also follows the bed of "iron formation."

At the east end of No. 2 vein, at the winze from the fourth to the fifth level, fault No. 64 was met with. The fault consists of a foot or two of fault breccia and gouge. The relation between the fault and No. 2 vein may be seen on the east face of the workings. The vein may be seen to come down vertically to the fault, which dips at an angle of 70° or 80° to the south. As the vein approaches the fault it also begins to dip to the south and finally follows the fault down. The winze being full of water we were not able to observe if the vein followed the fault down to the fifth level, but it was stated by the management that such was the case.

The "contact" fault was found occupying its usual position near the contact between the Cobalt and Keewatin series.

The Cobalt series on this level consists of conglomerate. Owing to a printer's error, the rock is incorrectly shown as slate-like greywacké on the plan of the fourth level.

Third Level.—(Elevation above sea level 896 feet.) No. 1 vein occurs immediately south of the main shaft. It has been followed for about 200 feet in the bed of Keewatin "iron formation" referred to in the level below. For some distance, the vein conforms in strike and dip to the "iron formation." The vein in the "iron formation" averages about an inch or two of barren calcite. It may still be seen on the northwest face of the drift.

This level is characterized by the occurrence of three vertical or steeply dipping faults, which on the plan have been named No. "64," Y, and Z. The faults consist of the usual fault breccia from an inch or two to as much as three or four feet in width. Here and there a calcite vein occurs in them, and they have been stoped to a limited extent. Some iron pyrites was noted in them.

Fault "No. 64" is almost vertical, striking about 18° north of west. It varies in width, being as wide as two feet in places, and consists of crushed rock and gouge. There were vugs of calcite in the fault. It is rusty in places owing to the decomposition of iron pyrites. A calcite vein of irregular width, and not continuous, follows the vein. The south branch of the fault enters the large stope in vein No. 2, but, as this vein was mined out, we could not determine the relation between the vein and fault on this level.

Fault Y strikes about west 50° north; at one place it dips 80° to the southwestward, while at the north end it dips 67° to the northeast. It has been stoped in places, and was said to carry small quantities of native silver. The fault consists of a fault breccia and gouge as wide as three feet; calcite cements together the rock fragments. In places almost pure pyrite forms a vein in the fault as wide as three inches and the pyrite is beautifully banded, as many as a dozen or more parallel bands occurring.

Fault Z strikes about west 32° north, and the southeast part was accessible. It consists of a fault breccia and gouge from an inch to 12 inches wide, and a calcite vein one to two inches wide occurs in it. Cobalt bloom was noted in the calcite vein in places.

There is no slate-like greywacké on this level save a few inches at the southwest part of the workings. Here the "contact" fault follows the bed for some distance.

A crosscut 660 feet long runs north along the east boundary. It is blocked by a concrete dam and we were not able to examine it, but the management reports it to be all in conglomerate of the Cobalt series.

Second Level.—(Elevation above sea level 948 feet.) The No. 1 vein occurs immediately south of the main shaft. It strikes a few degrees north of west. It has been followed for 180 feet west of the main shaft; as on the levels below it follows the same bed of Keewatin "iron formation." The vein where it occurs in the "iron formation" is from one to four inches wide.

This level shows how vein No. 1 and vein No. 2 are related to each other. Vein No. 2 strikes a little south of west for about 230 feet and runs into vein No. 1 almost at right angles. The last 50 or 75 feet of No. 2 vein, before it enters No. 1 vein, is not yet stoped out. The vein may be seen in the back where it is a strong one consisting of three to eight inches of pink calcite.

Fault No. 64 has been explored on this level in a drift which follows the fault continuously for 190 feet. In this drift it may be seen that the fault has a width of as much as six feet, consisting of a fault breccia and gouge. No calcite vein was noted, although there are some irregular stringers of calcite. At the east end of the drift a bed of finely-banded greywacké about three feet thick has been faulted by fault No. 64. The rock on the south side is the downthrow side. The bed of greywacké dips gently westward.

In one place on the level a vein of calcite one-quarter to one-half inch in width passed through fault No. 64 without being faulted. It is evident that this small vein is younger than the fault.

First Level.—(Elevation above sea level 981 feet.) Fault No. 64 was drifted on for about 190 feet and found to be similar in character to its deeper parts on lower levels. The bed of slate-like greywacké is also faulted in a similar manner to that noted on the second level. The rocks on the south side of the fault appear to have been faulted down about 10 feet.

At the northwest corner of the workings there is a vein called "vein blank"; it is north of fault No. 64. This vein has been stoped from the first level to the surface, but the company reported that it was not a very profitable vein. This is one of the few ore bodies which occur north of fault No. 64. On the O'Brien and Violet some ore was also found north of this fault.

No. 1 vein passes into the Keewatin "iron formation" as on lower levels.

The contact between the "iron formation" and the conglomerate of the Cobalt series is as sharply defined as a knife.

BEAVER CONSOLIDATED

The Beaver Consolidated Mines, Limited, has an authorized and issued capital of $2,000,000 in shares of the par value of $1.00. The mine has produced 6,031,448 ounces of silver, and had paid $710,000 in dividends. There are about 8.5 miles of underground workings, including drifts, crosscuts, winzes, raises, and shafts. The company ceased operations on the 31st of December, 1920, but the property was leased by the Coniagas, which company began operations in January, 1923.

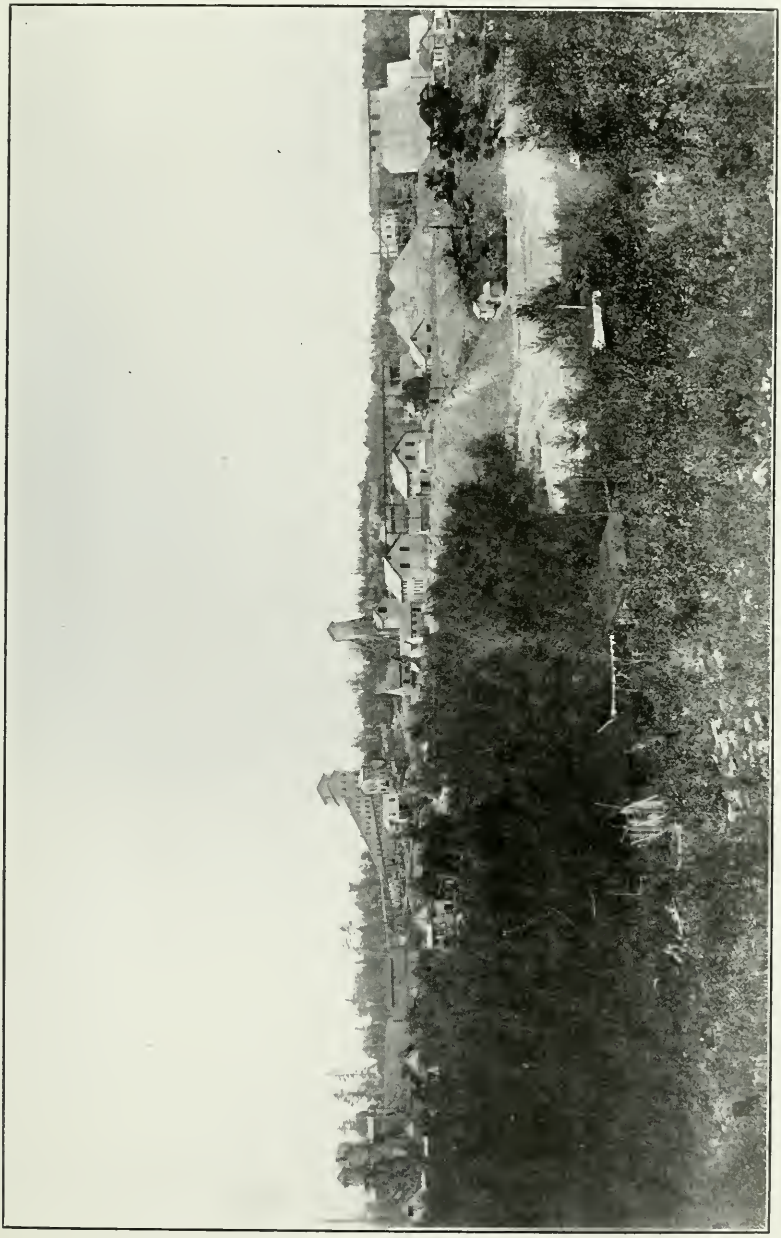


Fig. 30—Temiskaming and Beaver mines.

According to the annual report of the Beaver company for the year ending February 28th, 1919, the Beaver owned approximately seven-eighths of the capital stock of the Kirkland Lake Gold Mining Company, Limited, at Kirkland Lake, Ontario, which the Beaver purchased at a cost of $370,957.79.

The Beaver vein-system is the northward extension of the Temiskaming system, which property is contiguous to the Beaver on the south.

The silver ore at the Beaver occurs almost wholly at the top of the Nipissing diabase sill (vertical sections facing page 10). It is reported, however, by the Beaver management that 40,000 or 50,000 ounces of silver were obtained below the diabase sill on the 1,600-ft. level. This is the greatest depth below the surface at which silver ore has been found at Cobalt and is of interest for that reason. The remainder of the silver was mined above the 804-ft. level.

Regarding the occurrence of silver ore on the 1,600-foot level of the Beaver, the Ontario Department of Mines is indebted to F. L. Culver for the following information contained in a letter dated May 25th, 1921: "I am sorry that we did not keep an actual record of what was taken from the 1,600-foot level. However, I would say that it was possibly 40,000 or 50,000 ounces [of silver], but, assuming that you desire this for statistical purposes, I could not vouch as to the accuracy. I know we took out some high-grade and milled a lot of the product."

The central zone of the diabase sill at the Beaver or Temiskaming has not yet proved to be productive.

The management of the Beaver estimate that about three-quarters of the ore was obtained from within about 125 or 150 feet of the contact between the top of the Nipissing diabase sill and the Keewatin, the Keewatin being much more productive than the diabase. A little of the ore extended down into the sill to a depth of 275 feet, at which depth the veins became barren and narrower. The veins passed from the Keewatin down into the diabase without pinching out.

There are two main veins at the Beaver known as No. 3 and No. 5. These veins have an average strike of about north 22° east, and they extend southward into the Temiskaming. The two veins are parallel and are about 225 feet apart. Other veins occur, but these are the most important ones. The veins where they occur in the Keewatin dip steeply to the eastward, but about where they enter the top of the Nipissing diabase sill they become vertical, and, finally, in the sill itself, they dip steeply to the westward. The coloured section opposite page 10 shows the stoped parts of vein No. 5 on the Beaver, and of veins Nos. 1 and 3 on the Temiskaming.

While the veins at the top of the sill have an average strike of north 22° east, the vein which produced ore at the bottom of the sill strikes north 30° west, or about at an angle of 52° to veins at the top of the sill. None of the veins at the Beaver or Temiskaming have been followed downward continuously from the upper part of the diabase sill to the bottom of the sill.

The stopes at the Beaver, and also at the Temiskaming, are narrow compared with many stopes elsewhere in Cobalt which occur in the conglomerate, greywacké, and slate-like greywacké of the Cobalt series. This is due to the fact that the Keewatin basalt at the Beaver and Temiskaming did not fracture along the wall rock of the veins into innumerable tiny cracks. Hence the silver minerals did not penetrate far into the wall rock. The rocks of the Cobalt series, on the other hand, have generally been fractured more readily than the Keewatin rocks; hence the silver minerals were able to penetrate farther into the rock.

Owing to the irregular and erratic occurrence of the ore-shoots in the veins, the Beaver management did not publish in their annual reports a statement regarding the ore blocked out. At the time the property closed down, in December, 1920, it was stated that there were 14,000 tons of broken ore in the mine.

The ore-shoots of the Beaver are terminated at the north end of the property by a fault which strikes northwestward and dips steeply to the northeast. No ore occurs north of the fault. This fault is older than the period of ore deposition, because ore occurs in the fault; and some of the richest ore in the mine is said to have been mined from this fault, known as the Beaver fault. It is a most interesting, though unfortunate fact that the Beaver fault should limit the ore in a northerly direction on the property. Some veins extend to the north of the fault, but they are not productive of silver. Possibly the fault acted as an impermeable barrier and prevented the silver solutions from penetrating beyond it.

In examining the Beaver and Temiskaming workings, one is struck by the number of barren calcite veins; one is also impressed by the more or less erratic occurrence of ore-shoots in some of the productive veins.

The economic geology at the Beaver and Temiskaming mine has to do with but two main series, namely, the Keewatin and the Nipissing diabase sill. There are also lamprophyre dikes cutting the Keewatin. The Nipissing diabase sill intersects the Keewatin series; and the top and bottom of the sill have been encountered in the workings at depth. The Keewatin consists of basaltic lava flows with which is interbedded a bed of so-called "iron formation" resting in about vertical attitude. This bed consists of cherty rocks and greywacké, finely banded, and will be referred to as the chert bed. It pinches out at the north part of the Beaver and has a maximum thickness of 150 feet at the south end, where it continues southward into the Temiskaming property.

The rock along the west side of the chert formation is more or less impregnated with iron pyrites, some of it, as on the 297-ft. level, occurring in roundish or cyclindrical forms.

The chert bed is of little economic interest, except that in places, where it is cut by productive veins, the rock has become impregnated with thin films of native silver. This is owing to the fact that the chert fractured into innumerable cracks, and where the productive veins intersected the chert bed the native silver had a tendency to impregnate the chert along the tiny cracks, and thus to cause the stopes to be wider in the chert bed than they are in the basalt. The basalt did not fracture into the innumerable cracks which are found in the chert. Unfortunately the productive veins in the Beaver occur for the most part in the basalt and the Nipissing diabase. In the Temiskaming the productive veins scarcely touch the chert formation.

Owing to the enterprising management of the Beaver mine, the main shaft was sunk to a depth of 1,600 feet, so that it passed through the entire thickness of the Nipissing diabase sill and encountered the Keewatin series below the sill. The object of this deep work was to prospect the rock below the bottom of the sill. The shaft cut the top of the sill at a depth of about 468 feet, and cut the bottom of the sill at a depth of about 1,590 feet. Allowing for the dip of the sill, it may be estimated that the sill has a thickness of about 1,000 feet, in round numbers. About 1,900 feet of development work was done on the 1,600-ft. level of the Beaver mine, but, unfortunately, at the time of our examination this level was flooded and we were not able to investigate it. If the level were accessible, it would be interesting to find out if the chert formation is vertically below where it occurs on the top of the sill. By means of this chert formation it would be possible to show what movement, if any, had taken place between the hanging wall and footwall of the diabase sill.

An interesting feature of the geological structure of the Beaver mine is that it has been possible to prove that the diabase sill moved, during its intrusion, from the southeast to the northwest. This is shown by the inclusion of a great block of Lorrain granite, which was found at the top of the sill on the 456-ft. level. The granite inclusion is similar to the Lorrain granite which occurs about one-quarter of a mile southeast of the Beaver mine. As the sill moved towards the northwest it caught up this block of Lorrain granite.

The general structure of the rock formations at the Beaver is shown by the two verical sections AA and BB, opposite page 32. It may be seen from these sections how the Nipissing diabase sill intersects the Keewatin chert formation and the basalt. The chert formation must occur somewhere below the diabase sill, but, as previously stated, the workings which may show its location on the 1,600-ft. level were not accessible at the time of our examination, so that we were not able to locate it. The vertical sections show its supposed position below the sill.

Commencing with the lowest level, the 1,600-ft., the various levels of the Beaver mine may now be briefly described.

Beaver Mine Workings

1,600-ft. Level.—At the time of our examination of the Beaver in June, 1920. the 1,600-ft. level was flooded and no examination could be made. The plans furnished by the company show that about 1,900 feet of development work had been done. It is stated that the bottom of the Nipissing diabase sill was encountered in the shaft about ten feet above this level, that is, at a depth of 1,590 feet

The work on this level resulted in the discovery of a vein which is said to be six to eight inches in width. The vein is reported to contain native silver; and it is also stated that leaf silver is scattered through the wall-rock for a distance of about four feet on each side of the vein.[1] A little stoping was done on this vein, and about 40,000 to 50,000 ounces of silver were reported to have been obtained. A winze was put down on the vein to a depth of about 40 feet, and it was stated that high-grade ore was met with. While these results were encouraging because they showed that high-grade ore occurred at this depth, the work did not, however, disclose the presence of commercial ore of importance.

At this depth, namely, 1,600 feet, is the deepest zone in which silver has been found in the Cobalt camp; it is interesting to quote, concerning the discovery, from the company's annual report.

> The past year has brought most interesting changes to your mine. A very important discovery has been made—the discovery of high-grade ore at a depth of 1,600 feet. We might mention that this is the lowest depth at which values have been found in the Cobalt camp. A year ago the main shaft had reached a depth of 1,400 feet. During the year the shaft was continued to the lower contact [of the Nipissing diabase sill], the station cut at the 1,600-foot level, and crosscutting both east and west of the shaft uncovered a number of veins.
>
> Drifting on the vein west of the shaft brought us into silver values. This vein is from six to eight inches wide, rich in silver, and on both sides of the vein for a distance of about four feet the wall-rock is heavily impregnated with leaf silver. The discovery of ore at the 1,600-foot level of your property has caused a great deal of interest in the Cobalt camp, and while we are not yet in a position to say to the shareholders that it will actually make a new mine out of the Beaver, it is most encouraging.

---

[1] Annual Report, Beaver Mine, for year ending February 28th, 1917, p. 4.

1,400-ft. Level.—Fortunately this level was being worked at the time of our examination. It was the deepest level in the Cobalt area to which we had access. There are only 800 feet of development work, but enough was done to discover a strong vein at a distance of 500 feet west of the shaft. This vein, which occurs in the Keewatin below the Nipissing diabase sill, was followed for 225 feet and found to strike about north 30° west, with a steep dip to the east. It may be noted that its strike is at an angle of about 52° to the strike of the productive Beaver and Temiskaming veins which occur on the upper contact of the Nipissing diabase sill.

A raise was driven on the vein to a height of some 87 feet above the level, disclosing some niccolite and smaltite; but no silver was encountered, and the vein was still in the Keewatin greenstone. On the level the vein pinches and swells and varies from less than an inch in width up to eight inches or more. It consists mostly of pink calcite together with a little quartz. In places some almost pure smaltite occurs four or five inches in width, and it is reported that smaltite had been found as wide as a foot. The vein evidently occurs in a fault, because four or five inches of fault breccia and gouge occur on the walls of the vein, especially at the northwest part.

The vein occurs partly on the Beaver and partly on the Prince, contiguous on the west to the Beaver. The Prince is under option to the Beaver.

This vein on the 1,400-ft. level is thought to be the upward extension of the vein on the 1,600-ft. level in which a little ore had been discovered, as described in preceding paragraphs.

The crosscut on the 1,400-ft. level runs west for about 600 feet, extending into the Prince property for about 75 feet. The first 400 feet of the crosscut is Nipissing diabase, the remaining westward part being Keewatin basalt cut by lamprophyre dikes, and, at the west end, a very tough, medium-grained hornblende-diabase, probably of Haileyburian age. This hornblende-diabase was difficult to drill.

1,200-ft. Level.—A station is cut at this depth. The rock is Nipissing diabase.

900-ft. Level.—A station has also been cut at this depth, and the rock is likewise Nipissing diabase.

804-ft. Level.—The veins on this level are narrow, varying from about one-quarter of an inch to two inches and probably averaging less than an inch in width. They consist mostly of white calcite, and subordinately of pink calcite. The level is all in Nipissing diabase, and the veins occupy joint cracks. This is the lowest level on which ore is reported to occur in the Beaver at the top of the sill, some stoping having been done on No. 3 vein.

702-ft. Level.—A striking feature of this level is the manner in which the veins occupy joint planes dipping steeply to the westward. The level is all Nipissing diabase.

602-ft. Level.—This level is also completely in the Nipissing diabase sill. The joint planes in the diabase are very regular, and it is clear that the veins occupy the joint planes. The veins dip steeply westward.

530-ft. Level.—With the exception of the southeast part, all of the level is in Nipissing diabase. At the southeast corner the Keewatin has been met with and also the bed of finely-bedded chert (section BB, page 32). The cherty bed is impregnated with thin films or leaves of native silver near veins.

The discovery of the No. 3 vein (No. 19 on the Temiskaming) on this level is described in the annual report of the Temiskaming Mining Company for the year ending December 31st, 1914, on page 7. In view of its importance we may quote in detail regarding it. Mr. F. L. Culver, the general manager, in that report stated:—

> A few months ago, the management of the Beaver Consolidated started to drive a crosscut on the 530-foot level west to locate a vein which they had in early workings in levels above. About 130 feet from their shaft, they ran into a vein of high-grade ore in virgin territory. This vein was intercepted at a point about 55 feet north of the Temiskaming line. Arrangements were immediately made and a contract entered into with the management of the Beaver Company to drive south on this vein into the Temiskaming ground to see if the ore body carried there. The contract provides that, as soon as work commenced on the Temiskaming, the Beaver Company would receive sixteen dollars a lineal foot for drifting and nine dollars a cubic yard for stoping, all ore and waste to be returned through the Beaver shaft to the Temiskaming property. The Temiskaming boundary was reached in December and it has proven that this ore body continues into the Temiskaming ground [where the vein is known as No. 19]. The vein, which has been drifted on for a distance of about 60 feet, is from four to five inches in width carrying very rich ore. A number of tons of ore have been extracted so far which will carry values anywhere from 4,000 to 10,000 ounces of silver to the ton. The Beaver management have since proven that the ore in this same vein extends up to the 456-foot and the 396-foot levels of their property with a width of six to seven inches of very high-grade ore.

The 530-ft. is the lowest level on which the Beaver fault has been met with, the workings below this level not having been extended far enough northeastward to cut it.

The Beaver fault occurs at the northeast corner of the workings and has been followed for 210 feet. In this drift the fault breccia and gouge have a combined width of one to fifteen inches. In places the fault breccia (crushed wall-rock) is as wide as five feet, and along the wider crushed parts the rock in the back of the drift falls off very readily and is therefore dangerous ground to work in. There is a calcite vein from a fraction of an inch to one and a half inches in width in the fault, but the vein pinches out in places. No. 5 vein is a long one, extending from the south boundary of the Beaver northeastward about 575 feet. It extended up to the Beaver fault, and into the fault breccia, where it broke up into stringers. The Beaver fault appears to be older than the No. 5 vein.

About 270 feet east of the shaft, there is a barren vein consisting of many parallel stringers of quartz and calcite from an eighth of an inch to three or four inches in width, the combined width of the stringers being more than two feet.

456-ft. Level.—This level and the one above have the most extensive workings in the mine. About a third of the workings are in Nipissing diabase, the remainder being in Keewatin rocks.

An interesting feature of the level is the presence of a great block of Lorrain granite completely enclosed in the Nipissing diabase. It is evident that the granite block was caught up by the molten diabase sill during the time that the sill was being intruded through the older rocks. The main mass of the Lorrain granite occurs southeast of the Beaver mine; consequently it would appear that the molten diabase sill moved during its intrusion from the southeast towards the northwest. The inclusion of granite is at least 150 feet long and 65 feet wide. The stope, which follows a vein up into the granite mass, was not accessible, so that we were not able to find out how high above the level the granite extended. The granite does not, however, occur on the level above, namely, the 396-ft., nor does it occur on the level below, namely, the 530-ft. Where examined, it was noted that only a foot or two of the Nipissing diabase sill intervened between the top of the granite mass and the overlying Keewatin, so that it may be said that the granite inclusion practically floated at the top of the molten sill. Vein No. 2 cut through the granite inclusion, the Nipissing diabase, and the Keewatin rocks.

The chert formation has a maximum width of 155 feet. It is wedge-shaped in plan, gradually pinching out at a distance of 360 feet north of the south boundary of the Beaver. The bedding at the south end of the chert dips about 55° to the west. Near the shaft the chert is cut by a dike of lamprophyre which dips at very gentle angles.

The Beaver fault, which occurs at the northeast corner of the workings, has been drifted on for over 200 feet. It strikes northwestward, dips steeply to the northeast, and shows about eight inches of fault breccia and gouge. A vein occurs in the fault, and the management of the mine stated that some of the richest ore obtained was mined from the vein in the fault. This rich ore occurred where three productive veins ran into the fault, the veins entering at about right angles. The ore in the fault was obtained between the 456-ft. and the 396-ft. levels.

It is evident that the Beaver fault is older than the veins, since the productive vein referred to in the preceding paragraph occurs in the fault. But it would also appear that there has been a little movement along the fault after the veins were deposited, because one of the veins which crosses the fault at about right angles and extends beyond it, has been faulted about two feet.

The sinister influence of the Beaver fault in regard to ore shoots is well illustrated on this level. While some of the veins extend to the northeast of the fault no silver ore occurs to the northeast of it. For example, one of the main veins of the mine, the No. 5, extends to the northeast of the fault about 250 feet, but is not productive along that part. It would appear that the absence of silver ore in quantity on the properties which are immediately north of the Beaver is due to the presence of the Beaver fault. This fault may have acted as an impermeable barrier which prevented the silver solutions from circulating to the northeast.

The direction and extent of the displacement along the Beaver fault is not known.

396-ft. Level.—The workings are almost entirely in the Keewatin rocks, except at the northwest corner, where the Nipissing diabase has been met with in two drifts and a crosscut. The bed of chert has been encountered, showing dips of 51° to 63° to the west, and the workings are such that this bed has been proven to pinch out at a distance of about 350 feet north of the south boundary of the property. The Keewatin basalt along the west side of the chert bed is partly impregnated with iron pyrites.

The Beaver fault also occurs on this level and has been followed for about 200 feet. It strikes northeastward and dips at one place 61° to the northeast. A vein of calcite and quartz, four or five inches wide, occurs in the fault. There are some four inches of fault breccia and gouge in the fault.

The plan of this level shows a fine-grained lamprophyre dike, which was met with while following No. 5 vein. On the south wall of the dike there is a fault showing about a foot of fault breccia and gouge. The vein passed through this dike and fault.

347-ft. Level.—Compared with levels below, this level has very little work done. The No. 5 vein has been followed for over 600 feet; and there has been about 125 feet of drifting done on the other veins west of the No. 5. The level is all in Keewatin rocks, including the chert formation, the bedding of which dips westward about 65°.

297-ft. Level.—The workings on this level are almost as extensive as are the workings on the 396-ft. and 456-ft. levels. The rocks encountered are all Keewatin and consist of basalt and the chert bed.

The Beaver fault has been drifted on for 275 feet, and shows several inches of gouge and fault breccia. There is a calcite vein in the fault which pinches out entirely in places.

The rock immediately west of the chert formation is impregnated with iron pyrites, some of which occurs in roundish or cylindrical nodules.

235-ft. Level.—This level has about 800 feet of workings, all in Keewatin basalt.

199-ft. Level.—The workings are comparatively extensive, and are all in the Keewatin except at the northwest corner where the Nipissing diabase was met with in a crosscut. The Nipissing diabase is fine-grained at its contact with the Keewatin. The contact is about vertical, and there has been some movement along the contact, as is shown by the presence of two or three inches of fault breccia and gouge.

Some of the veins on the level consist largely of quartz with subordinate quantities of clacite.

The chert formation is narrow—about 35 feet in width.

77-ft. Level.—The level consists of an east and west crosscut about 600 feet long, which has intersected about a dozen non-productive veins, most of which are quartz. At the east end of the crosscut there is a quartz vein twelve to fifteen inches wide.

The chert bed on this level is about 50 feet wide; some of the chert is almost black.

SENECA-SUPERIOR

The Ontario Department of Mines is indebted to W. E. Segsworth for the following description of this property. As Mr. Segsworth was not only largely responsible for the discovery of the Worth vein, but was also managing director of the company during the period of its operation, he is in a position to write authoritatively regarding the property.

The Seneca-Superior Silver Mines, Limited, was incorporated in October, 1911, to acquire and operate three leases under Peterson Lake. These leases are shown on the plan (Fig. 36), and have an area of approximately ten acres each. One was situated under Peterson lake proper and was called the upper lease. The two contiguous leases under Cart lake were collectively referred to as the Cart lake lease, and had a combined area of about 21 acres. It was from this Cart lake lease that all the production came. The surface was covered with water except a 33-foot road allowance around the shore.

These leases were held on a royalty of 25 per cent. of the gross smelter returns to be paid to the Peterson Lake Mining Company. They were formerly operated by the Kerry Mining Company of Rochester, New York. This company did most of its exploration on the upper lease, and found small patches of high-grade ore, but no ore in commercial quantities. The upper lease was abandoned by the Seneca Company after a careful examination had been made, and subsequent exploration by the Peterson Lake Company did not disclose ore in commercial quantities.

The Seneca Company commenced operations in January, 1912, and confined its work to the Cart lake lease. The Kerry Company had previously trenched all the shore line, had done some diamond-drilling, and had sunk several test pits and two shafts. No. 2 was down 50 feet and No. 1, 110 feet. Three short drifts had been run at the 100-foot level in shaft No. 1. None of this work disclosed any ore on the Cart lake lease.

The plan showing the workings under Cart and Peterson lakes is in the pocket at the back of this report.

Before commencing operations, the Seneca Company's officials made a close study of the geology and ore deposits in the Cart lake area. The accompanying geological sections (Fig. 31), were made before operations commenced, the contacts in the Seneca No. 1 shaft and the position of the Worth vein being added subsequently. This study shows a flat dish-shaped bed of conglomerate of the Cobalt series resting on Keewatin greenstone. The bed was about 350 feet deep at its deepest part. The diabase sill, the remnants of which in this vicinity form Diabase mountain, at one time lay over the conglomerate with its lower surface perhaps 100 to 200 feet above the lake level, or 450 to 550 feet above the Keewatin contact. A bed of slate-like greywacké, locally called slate, occurred at 70 feet above the Keewatin contact. This bed dips at more gentle angles than the dip of the Keewatin floor, and it rests on, or is near, the Keewatin

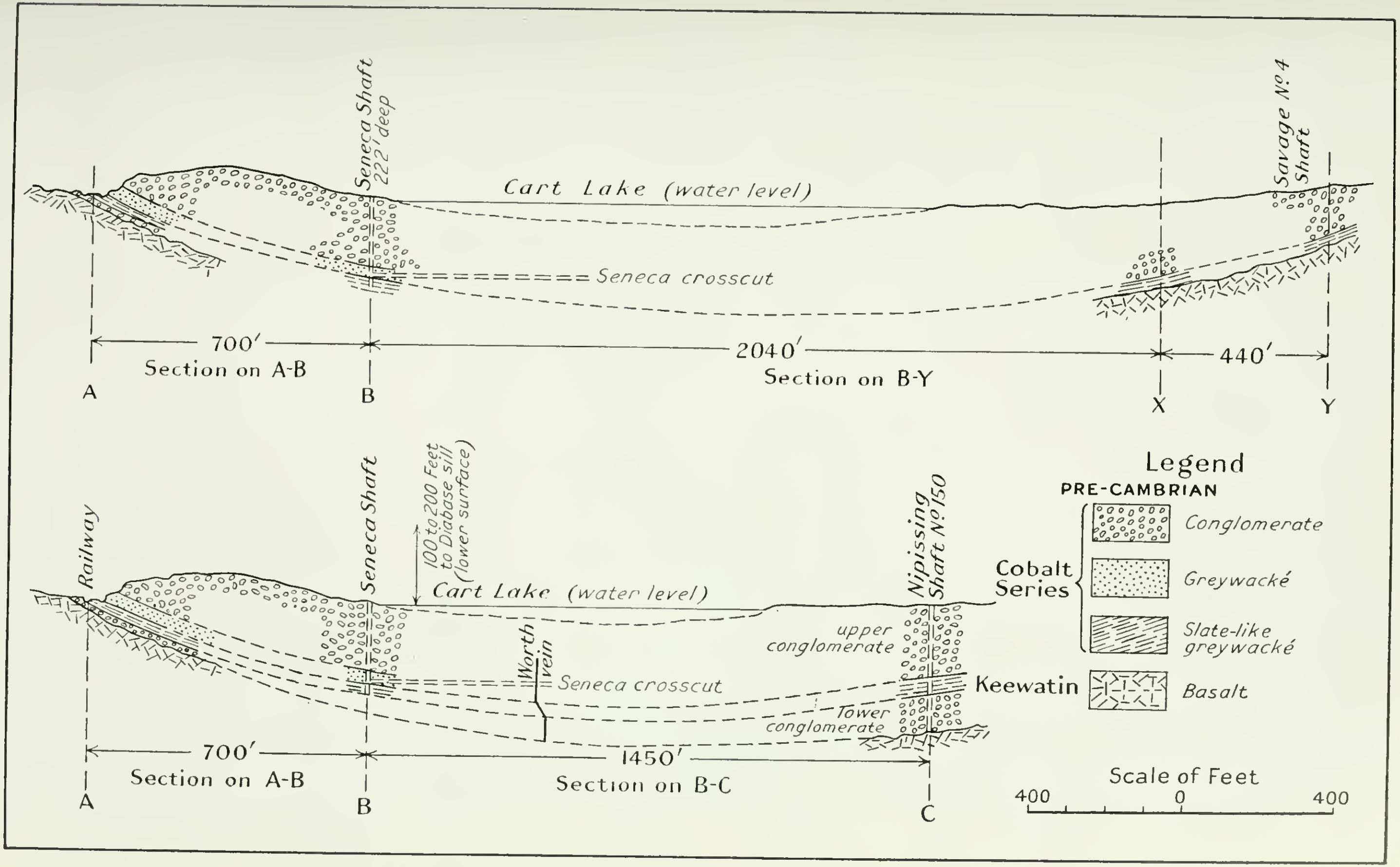


Fig. 31—Vertical sections through the Seneca mine, prepared by W. E. Segsworth.

contact around the rim of the basin. The bed was identified in the Little Silver shaft of the Nipissing, the Nipissing shaft No. 150, and in the Savage and Provincial mines. In these properties several instances were found where veins contained high-grade ore above, and in, this slate bed, and the same veins underneath the slate were rich in cobalt but contained little if any silver. The theory was therefore adopted, and afterwards proved true, that in this particular basin the locus of the richest ore was just above the slate bed. Many of the ore-bearing veins on the surrounding properties, namely, the Nipissing, Savage, and Provincial mines, had a northeast strike. It was therefore decided to sink the No. 1 shaft to the slate bed, and drive a crosscut perpendicular to the strike of the veins just above the slate.

Operations were commenced, following out this plan, in January, 1912. The slate was reached at 200 feet, a sump cut, a level established, and a crosscut, in a southeasterly direction, started at 200 feet. On October 10th, 1912, this crosscut had reached a distance of 439 feet from the shaft, and at that point encountered a small stringer of ore which, in the next round, broke into the Worth vein.

The development of this vein disclosed an oval-shaped vertical lens, or ore-shoot, of high-grade ore with a northeast strike. This lens had a maximum horizontal length of 440 feet on the Seneca, and extended about 50 to 60 feet into the adjoining Gould Consolidated (Mercer), giving it a total length of 500 feet. The lens rested on the Keewatin contact and had a maximum height of 250 feet above the contact. The upper limit of the lens would be about 200 to 300 feet below the bottom of the diabase sill.

The average assays on the stope maps prove that the ore was richest in the upper levels. The Cobalt content was greatest in the lower levels. The first level just skimmed the top of the ore-shoot. The ore in the top of the vein was calcite, free from cobalt, rich in native silver, and about four inches wide. The ore near the contact was a dense hard smaltite ore, practically free from visible native silver or calcite. The pillars on the stope map represent barren areas in the vein. These barren areas were larger than shown by the pillars.

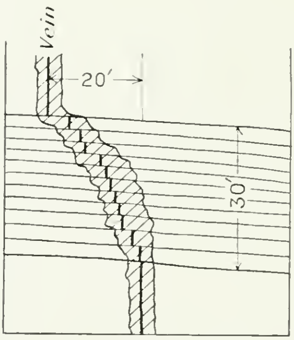


Fig. 32—Illustrating what happened to "Worth" vein, Seneca mine, when vein passed through a 30-ft. bed of slate-like greywacké. Drawing furnished by W. E. Segsworth.

The slate bed between the second and third levels furnishes the most interesting feature of this ore deposit. At the southwest boundary, it is 30 feet thick, and thins out to a point 230 feet to the northeast. This slate profoundly affected the deposition of the ore. Above the slate and in its upper part, the ore assayed 3,500 ounces of silver per ton, but immediately below, the silver content dropped to 2,000 ounces per ton, and from there decreased in value to 900 ounces near the Keewatin contact. This phenomenon was beautifully illustrated on the third level where, in drifting to the northeast, the assays jumped from 2,000 ounces to 3,800 ounces per ton immediately the drift passed from under the slate bed.

The slate bed has a strong parting along the bedding plane and, as shown in the transverse section of the vein, "step-faulting" occurred in the slate, the total throw being 20 feet (Fig. 32). The slipping of the layers over each other left the structure quite open, and converted the slate bed into a favourable water course. The wall-rock in the conglomerate was dense and hard and, compared with the slate, did not offer favourable conditions for the circulation of solutions. It is probable that the silver solution in its descent from the diabase sill was diluted or escaped in the slate. On the other hand, the increase in cobalt under the slate might indicate that the cobalt was deposited before the silver and before the faulting in the slate had opened it to the circulation of solution.

Apart from this step-faulting in the slate, no faults of any importance were found.

The Seneca vein was rather unique in that no mill-rock was found in the conglomerate walls. What small amount of ore was milled was the undersize from the sorting tables, too small to be handpicked, the large pieces with vein matter attached which could not be cobbed, and a little disseminated ore from the Keewatin.

A winze was sunk 75 feet below the fourth level (Fig. 33), and the vein was found to feather out into numerous small stringers and disseminated ore and then to disappear in the Keewatin. The average assay of 1,872 tons milled from this rock below the fourth level was 16.5 ounces per ton.

When the Seneca company abandoned operations, it left a small amount of this ore in place as it could not be profitably extracted and milled owing to the 25 per cent. royalty payable to the parent company.

The rocks below the fourth level, which were tapped by the winze above referred to, form an interesting study. As shown by the vertical section (Fig. 33), the winze encountered a bed of slate, immediately below the level, having a thickness of 15 feet, 6 inches. Below the slate, a bed of conglomerate was found. This conglomerate is composed almost wholly of fragments and boulders of the underlying Keewatin, although there are a few granite pebbles and boulders. Northeast of the winze the slate bed gradually rises and becomes thinner, and when it reaches the forth level it is only six feet thick, and is found resting directly on the Keewatin. Thus there is at the bottom of Cart lake a basin or trough in the Keewatin. This basin was first filled with conglomerate of the Cobalt series, the conglomerate consisting almost wholly of Keewatin fragments and boulders together with a few granite pebbles and boulders. Conditions of deposition then changed and a bed of slate-like greywacke, locally called slate, was laid down. Above the central parts of the basin, the slate rested on the conglomerate, but higher up on the sides of the basin the slate was deposited directly on the Keewatin (Fig. 33). There is thus very good evidence to show that this basin was not caused by folding, but was formed in the usual way by erosion before the Cobalt series was laid down.

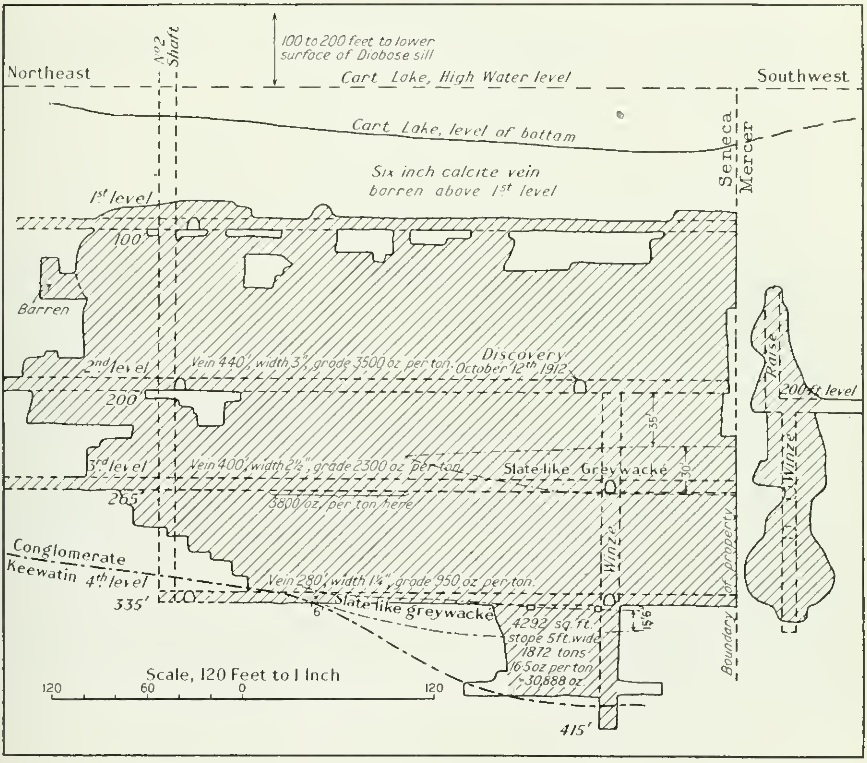

No 2 Shaft
100 to 200 feet to lower surface of Diobose sill
Northeast
Cart Lake, High Water level
Southwest
Cart Lake, level of bottom
Seneca
Mercer
Six inch calcite vein barren above 1st level
1st level
100'
Barren
2nd level
Vein 440', width 3", grade 3500 oz per ton.
Discovery October 12th 1912
200'
Raise
200 ft. level
35'
Winze
3rd level
Vein 400', width 2½", grade 2300 oz per ton.
Slate-like Greywacke
30'
265'
3800 oz. per ton here
Conglomerate
Keewatin
4th level
Winze
Boundary of property
335'
Vein 280', width 1¼", grade 950 oz per ton.
6'
Slate-like greywacke
15'6"
4292 sq. ft.
stope 5 ft. wide
1872 tons
16.5 oz per ton
= 30,888 oz.
Scale, 120 Feet to 1 Inch
120
60
0
120
415'

Fig. 33—Stope section of Worth vein, Seneca mine, prepared by W. E. Segsworth.

The Worth vein was the only ore-bearing vein found on the Seneca property. In all, 7,665 feet of exploration work was done in an effort to find other productive veins, but without result. The plan of the mine shows this exploration, which covered practically the whole of the property. The Seneca presents one of the few instances in the Cobalt area of a paying mine being established on a single isolated ore-shoot.

All profitable ore was extracted early in 1916, and the mine was closed, the plant sold, and the lease abandoned that year. In a period of less than four years the mine produced 5,639,093 ounces of silver from the one ore-shoot.

The following figures from the annual report of the company at the end of the year 1916 are interesting:—

Production 5,639,093 ounces at 55.3 cents per oz.		$3,118,938.54
Less:		
Royalty	$751,381.87	
Smelter deductions	68,164.81	
Freight and treatment	108,112.21	
		927,658.89
Gross receipts from shipments		$2,191,280.65
Less:		
Mining and operating	$576,606.05	
Head office charges	78,510.86	
War tax	15,245.39	
		670,362.30
Net profits on operations		$1,520,918.35

The costs over the whole operation were:		Cents per oz.
Royalty	$751,381.87	13.33
Smelter deductions	68,164.81	1.22
Freight and treatment	108,112.21	1.93
Mining and operating	576,606.05	10.22
Administration	78,510.86	1.40
War tax	15,245.39	.28
Total cost	$1,598,021.19	28.38
Profit on operation	1,520,918.35	26.92
Gross value	$3,118,939.54	55.3

From the operating profit of $1,520,918.35, as above, plus the money realized from the sale of the capital stock, the company paid $1,582,211.62 in dividends, or $3.30½ per share on its issued capital of 478,884 shares. The capital stock was sold for seventeen and a half cents per share.

The officers of the company were: S. Harry Worth, director and president; F. W. Zoller, director and vice-president; R. F. Segsworth, director and secretary-treasurer; W. E. Segsworth, managing director; Alvin H. Dewey, director; R. H. Lyman, mine manager, and T. D. Maguire, mine captain.

PENN-CANADIAN

Prior to its acquisition by the Penn-Canadian Mines, Limited, which was incorporated on April 24th, 1912, the property was worked by two other companies known as the Big Pete Canadian Mines and the Cobalt Central.

The total output of silver under all companies amounted to 3,752,610 ounces of silver.

When the property was examined during the latter part of the year 1920 it was not in operation, but most of the mine was accessible, and we were able to map all of the levels except the sixth. The information regarding this was kindly furnished by Balmer Neilly, manager of the Penn-Canadian company when the mine was last in operation.

The structure of the rocks at the Penn-Canadian and Bailey is shown in the vertical section facing page 40. The Nipissing diabase sill was met with down to the third level where it rests on a gently dipping bed of slate-like greywacké of the Cobalt series about 40 feet thick. Below the greywacké is conglomerate of the Cobalt series from a few feet to about 35 or 40 feet in thickness. The average thickness of the conglomerate and slate-like greywacké combined is about 70 feet. Below the Cobalt series is the Keewatin, which was not productive. The Cobalt series is resting at an unusually flat angle, the dip being about 6° or 7° to the northeastward. The Nipissing diabase sill has for the most part forced its way along a single bed of the slate-like greywacké.

The Ontario Department of Mines is indebted to Mr. Neilly for the following description of the property.

The ore bodies so far developed were found on that portion of the property lying west of Glen lake or under Diabase mountain. As the latter name suggests, the diabase outcrops on the surface and the original discoveries were made in that formation; these same ore bodies produced some much decomposed rich ore down to a horizontal fault which was 20 or 30 feet above the bottom of the diabase sill.

The displacement of this fault was about 90 feet to the northwest. For 20 feet above the fault there was little ore, and the 20 or 30 feet of diabase below the fault was practically barren, although the veins were quite persistent.

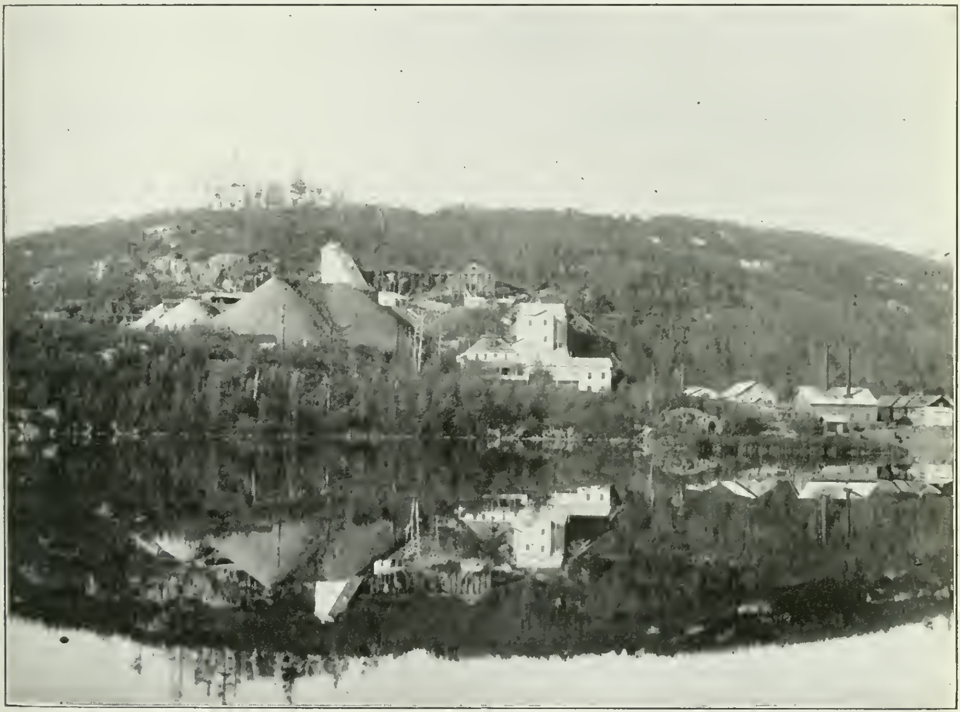


Fig. 34—Penn-Canadian and Bailey mines; Glen lake in foreground.

Below the diabase is the slate-like greywacké of the Cobalt series, having an average depth of about 40 feet. Below the slate-like greywacké is the conglomerate of the Cobalt series varying in thickness from a few feet to 35 or 40 feet.

The downward extension of the "Big Pete", or discovery vein, was mined in the Cobalt series and found to occupy a long syncline with its axis a little east of north. Another main vein-system was developed in a syncline running at about right angles to the "Big Pete" vein.

From these two systems practically all the production to date was obtained.

To the northwest of the present workings there is evidence of another syncline, and, when work was discontinued at the time of the strike in 1919, a crosscut was being driven in the conglomerate of the Cobalt series in that direction.

The property situated east of Glen lake is practically undeveloped, except for a shaft sunk to a depth of 120 feet in the diabase. On the northern half of this lot the diabase rests on the Keewatin, but, toward the south and adjoining the Foster mine, such work as has been done indicated a considerable depth of the Cobalt series. This area of approximately 20 acres can be looked upon as almost virgin ground and undoubtedly will be further developed some time in the future.

DRUMMOND (COBALT COMET)

To the end of the year 1922, the production from this property amounted to 3,707,137 ounces of silver.

The property was bought by the Cobalt Comet Mines, Limited, the latter company having been incorporated on April 16th, 1913, with a capital of $1,000,000.

The mine has not been in operation during recent years, and the Ontario Department of Mines is indebted to R. W. Brigstocke for the following account of the discovery of the mine, and description of the rocks and veins. Mr. Brigstocke was manager of the property until it was taken over by the Cobalt Comet Mines, Limited, in 1913.

Mr. Brigstocke discloses the important fact that the Cobalt series is only about 50 feet thick. And, as the Cobalt series is the only productive horizon, it is seen that the ore zone is a very shallow one indeed.

In the autumn of 1904, one year after the discovery of ore at Cobalt, the Drummond Mines was staked by M. P. Wright for Messrs. Drummond and associates of Montreal, amongst whom was Dr. W. H. Drummond, the well-known Canadian poet.

Mr. Wright found a calcite vein at the northerly end of the Kerr Lake property. This was the birth of that important section of the Cobalt camp known as the Kerr Lake section.

The geology of this section has been fully described in the government reports. As far as the Drummond Mine is concerned the southerly claim consisted of a small portion of Nipissing diabase, a small portion of conglomerate of the Cobalt series, and the remainder of Keewatin. The northerly claim consisted almost entirely of Nipissing diabase.

The conglomerate was the only rock in which ore was found, and it was not much more than 50 feet thick.

During the winter of 1904-5 a small shaft was sunk on the vein which Mr. Wright had discovered, but the result was disappointing. Work accomplished afterwards revealed no ore of importance. This was a strong calcite vein containing smaltite and niccolite and low silver values.

In the spring of 1905 further prospecting exposed the veins that constituted the birth of the Drummond Mines as a producer. There were two veins 6 feet apart, and a small one in the centre consisting of calcite, smaltite, and silver, but very little niccolite. Some portions yielded up to 14 inches in solid smaltite containing only 200 ounces of silver and over 50 per cent. arsenic by the carload. This was exceptional, the general tenor being high-grade ore assaying up to 6,300 ounces of silver per ton by the carload.

Other veins were also found extending under the lake which produced high-grade ore.

The walls of all the producing veins yielded mill-rock. In places sheets of silver extended into the walls many inches.

The large producing veins of early discovery extended over 400 feet in length, which somewhat compensated for the shallowness of the conglomerate which, as already stated, is not much more than 50 feet thick.

On these veins a shaft was sunk to a depth of 200 feet, and levels opened up at 50, 100, and 200 feet.

No ore was found below the conglomerate which was, in the shaft, 50 feet deep. A small calcite vein extended downwards into the Keewatin, but no ore was found.

About the time that these early discovered veins were nearing exhaustion of high-grade ore, the whole property had been thoroughly trenched to bed rock and apparently nothing of importance was forthcoming.

A second lease of life was, however, in store. The ground between the original workings and the south boundary was considered worthy of intensive exploration. Believing that the conglomerate existed underneath some heavy overburden and below the diabase sill, a shaft was sunk on a small barren vein in the diabase. The conglomerate was found at a depth of about 75 feet, a level driven, and the shaft continued to a depth of 125 feet, where another level was driven. A patch of ore was found on each level, having no connection with one another.

In the meantime the old trenches were being cleaned out and the ground cut up into 50-foot squares. A vein was found about 20 feet long and feathering to nothing at each end; it was about 2 inches wide in the centre and contained 2,000 ounces of silver to the ton.

The 75-foot level of these new workings was extended about 60 feet to cut the vein, which was found to be about 3 inches wide of high-grade ore. The same thing occurred on the 125-foot level.

This vein was followed and other veins disclosed, resulting in the discovery of several high-grade veins which yielded their share of high-grade ore and mill-rock.

In 1913 the mine was sold to the Cobalt Comet Mines, Limited, which carried on successfully to the end.

RIGHT OF WAY

The Right of Way Mines, Limited, has a capital of $2,000,000 of which $1,685,500 has been issued. The shares have a par value of $1.00. The company has produced 2,961,353 ounces of silver and has paid $252,825 in dividends to the end of the year 1922.

The company worked the "right of way" of the Temiskaming and Northern Ontario railway at the north end of Cobalt lake, and at the south end. At the north end the extension of the main La Rose vein was mined, while at the south end veins from the Silver Queen and Townsite were operated. The property was not being worked in the year 1921.

The workings north of Cobalt lake will first be described; the plans of this part are shown on sheet No. 31a-14.

Workings North of Cobalt Lake

Most of the two important levels, the 83-ft. and the 143-ft., were dammed off by concrete dams, making them inaccessible. The writer regrets that he was not able to examine this part of the mine; it is reported that the junction of the main La Rose vein and the Cobalt lake fault was met with during mining operations in these levels. It is unfortunate that there are no published records, in so far as the writer is aware, concerning the structural relation of the main La Rose vein to the Cobalt lake fault. The writer, however, obtained the following information from D. Angus, who was at one time in charge of the Right of Way. Mr. Angus states that La Rose vein entered the Right of Way property and continued southwestward, finally running into the Cobalt lake fault; that it followed the fault for 25 or 50 feet, and that it then turned south and gradually left the fault. The part of the vein in the fault and northeast of it was productive, but the part to the south of the fault was not productive and appeared to pinch out. It may be added that La Rose vein together with its southwestward extension into the Right of Way was on the southeast side of the Cobalt lake fault. The vein has never been found on the northwest side of the fault.

Judging from the verbal descriptions which the writer has obtained regarding the structural relation between the main La Rose vein and the Cobalt lake fault, it is evident that the vein is younger than the fault.

The Right of Way shaft, No. 2, is about 280 feet northeast of the north end of Cobalt lake. There are four levels from this shaft, at 83, 143, 358, and 410 feet below the collar of the shaft. The lowest level, the 410-ft., is reached by a winze from the 358-ft. level. The winze was said by the management to extend some distance below the 410-ft. level; it was flooded at the time of our examination, but as the rock below the 410-ft. level is Keewatin it would not appear to have much economic significance.

410-ft. Level.—The level consists of a drift about 70 feet long in the Cobalt lake fault. No cobalt bloom was noted in the fault, although there are irregular stringers of calcite in it.

The bottom of the Cobalt series occurs at the winze, so that these rocks have a thickness of about 410 feet on the north side of the Cobalt lake fault.

The Chambers-Ferland made use of this level to operate their property to the north of the Right of Way. With the exception of the drift on the Cobalt lake fault, the entire level is on the Chambers-Ferland property. The level is described in that part of the report dealing with the Chambers-Ferland.

358-ft. Level.—This level was also used by the Chambers-Ferland to work their property to the north of the Right of Way. The level is described on page 165.

143-ft. Level.—Practically all of the level was dammed off by a concrete dam, so that only the crosscut for 100 feet northeast of the shaft could be examined. This part of the level is on the south side of the Cobalt lake fault. The contact between the Keewatin and Cobalt series occurs about 10 feet north of the shaft, and strikes northeastward. In the shaft the contact occurs about 4 feet above the floor of the crosscut. About 60 feet northeast of the shaft, there is a bed of slate-like greywacké one foot thick. The dip of the Cobalt series may be readily ascertained from this bed, and it is seen to be dipping about 20° to the northwestward. There is a crushed zone along this bed of slate-like greywacké, indicating some slight movement, how much was not ascertained. Above the bed of slate-like greywacké is quartzite.

83-ft. Level.—The north part of the level was dammed off by a concrete dam; the south part was accessible. The latter consists entirely of the Cobalt series except a short crosscut at the east side, in the Chambers-Ferland ground, which consists of Keewatin. The Cobalt series dips at about 10° to the northwest.

About 10 feet north of the shaft, there is a minor fault dipping 20° to the northwestward. There are no veins except a small barren calcite one at the south end of the workings. From this level the Chambers-Ferland did some work on its property to the north.

Mine Workings South of Cobalt Lake

The Right of Way mine at the south end of Cobalt lake was worked from two shafts, Nos. 3 and 4. There are two levels, the upper one of which is known as the 75-ft. level. This level consists of a crosscut more than 1,700 feet long, running parallel with the railway track. At the time of examination, early in August, 1921, the level was partly flooded, and we were only able to examine the north half of the workings for a distance of about 800 feet. The crosscut in this north part of the workings encountered five veins, four of which have been more or less stoped. The veins strike northwestward. The one which is 340 feet north of No. 3 shaft has been stoped for a width of 10 to 20 feet. There was water in this stope 30 or 40 feet below the level, at the time of examination. On this level a fault may be seen intersecting this vein. The fault strikes northward, and dips at an angle of 37° to the east. Its relation to the vein could not be worked out.

The stopes on the other three small veins are narrow, 5 or 6 feet in width. At the north end of the property there is a vertical fault, which has a fault breccia and gouge 1 to 12 inches wide. A small vein of calcite with cobalt bloom parallels the fault.

The north end of the crosscut follows a fine-grained greywacké and slate-like greywacké for about 550 feet; to the south of the slate is conglomerate as far as we could explore. Keewatin is reported at the south end of the crosscut. The upper part of No. 4 shaft is conglomerate, below which is the bed of greywacké and slate-like greywacké to the 75-ft. level, and for a few feet below.

The first level of the Right of Way is about the same elevation as the second level of the Silver Queen.

The second level of the Right of Way was not accessible.

SILVER QUEEN

The Cobalt Silver Queen, Limited, has a capital of $1,500,000, all of which has been issued. The par value of each share is $1. The company has produced 1,225,111 ounces of silver, and has paid $315,000 in dividends to the end of the year 1922.

At the time of examination in August, 1921, the property was idle, although the rock dump was being shipped.

The workings in this mine are not extensive, as the plans of the levels show. The Cobalt series is shallow, and there are only two veins of importance on the claim. There are three levels, the two lower of which were flooded and inaccessible in the year 1921.

The property was worked from an inclined shaft, which dips southward at an angle of about 60°. The main vein strikes a few degrees north of west. In the conglomerate and greywacké of the Cobalt series this vein is about vertical, but, on entering the Keewatin, it flattens out and dips at an angle of about 60° to the south. At the station on the first level, the vein may still be seen in the Keewatin; it is in places 5 or 6 inches wide consisting mostly of calcite. A drift follows this vein westward from the shaft along the first level for 600 feet; unfortunately at the time of examination this drift was blocked, but it was reported that the drift was all in Keewatin and that the calcite vein persists throughout and contains in places 3 or 4 inches of smaltite.

A fault, corresponding in position to the "contact" fault, occurs on the first level, but it is poorly defined and shows, as a general rule, only an inch or two of fault breccia and gouge.

The other vein on the property occurs at the northeast corner of the claims; it extends into the Townsite, and thence into the Right of Way mine.

The second level was inaccessible, but it was reported that the contact between the Keewatin and the Cobalt series is about 270 feet east of the shaft. The second level of the Silver Queen corresponds to the first level of the Right of Way.

In 1921 the Cobalt Silver Queen was under lease to Mr. W. J. Post, to whom the writer wishes to express thanks for courtesies extended during the examination.

CHAMBERS-FERLAND (ALADDIN)

The Chambers-Ferland mine was operated by the Aladdin Cobalt Company, Limited, which was incorporated on August 23rd, 1912, with a capital of $500,000 in shares of a par value of $5 each. The company has paid in dividends $75,000. The Aladdin Company has been liquidated, and superseded by the Kirkland Lake Proprietary (1919), Limited, which is also the holding company of the Tough-Oakes Gold Mines, Limited, and the Burnside Gold Mines, Limited.[1]

The old Chambers-Ferland produced 1,107,810 ounces, and the Aladdin produced 1,067,658 ounces of silver.

The main workings of the Chambers-Ferland were operated from No. 4 shaft. The veins in this part of the mine are mostly the eastward extensions of veins Nos. 98 and 490 of the Nipissing, and these veins produced most of the ore for the Chambers-Ferland.

At the southwest corner of the property certain veins were worked, using the No. 2 shaft of the Right of Way. These workings are not connected with the No. 4 shaft workings.

---

[1] Annual Report, Ont. Dept. Mines, Vol. XXX, pt. I, p. 107.

Some work has also been done on the Chambers-Ferland, which lies north of the northwest corner of the O'Brien mine.

The No. 2 shaft on that part of the Chambers-Ferland south of La Rose was not examined.

Workings from No. 4 Shaft

The most productive vein at this end of the property, in fact on the entire property, is reported to be vein No. 15. This vein is said to be the eastward extension of vein No. 98 on the Nipissing. Vein No. 98 is the most important branch of the Meyer vein of the Nipissing. Vein No. 15 was followed for about 200 feet eastward from the Nipissing boundary, but it was only stoped for about 80 feet east of the boundary.

The next important vein on the property is No. 14. This vein is the eastward extension of vein-system No. 490 on the Nipissing—a very important system on the Nipissing property. It is reported to have produced some 100,000 ounces of silver on the Chambers-Ferland. These two veins, Nos. 15 and 14, are the tale-end, so to speak, of two very productive veins on the Nipissing.

On this part of the Chambers-Ferland mine there are six levels, namely, 525-ft., 480-ft., 453-ft., 425-ft., 350-ft., and 275-ft. These levels may now be described, beginning with the lowest. Unfortunately most of the levels were inaccessible, due to concrete dams at the north ends of the workings. During the time of our examination, we gained access to the mine from the fourth and sixth levels of the Nipissing mine.

525-ft. Level.—The level is reached from a winze on the 425-ft. level. It was flooded at the time of our examination. The fault known as No. 64 on the Nipissing was reported to have been met with near the south end of the level, and it was drifted on for about 40 feet.

480-ft. Level.—This is a small level with about 250 feet of workings operated from winze D. It is about 30 feet above the sixth level of the Nipissing. In our examination we entered the level by way of a raise at the north part of the sixth level of the Nipissing.

There are a number of short veins on the 480-ft. level. No. 6 at the north end has been followed 50 feet northeast of the Nipissing boundary line. Near the northeast end, it meets a prominent fault. The vein goes through the fault and has been followed to the northeast of the fault for about 10 feet, although on the northeast side of the fault the vein is a mere crack showing nickel and cobalt bloom.

Vein No. 4 may still be seen in the back of the drift and shows 1 to 2 inches of smaltite and calcite. Vein No. 3 has less than half an inch of smaltite. Veins Nos. 1 and 2 join just before encountering the fault.

The fault referred to in preceding paragraphs, and shown on the plan of this level, may be the northward extension of what has been called the "valley" fault on the Nipissing. It has a fault breccia of 12 or 15 inches in places, and a gouge fractions of an inch wide. It strikes a few degrees east of north and dips at an angle of 76° to the eastward. The fault is a reverse one with a displacement of about 33 feet. On the Nipissing, however, at winze No. 73-4014, a distance of 350 feet south of the Chambers-Ferland 480-ft. level, the "valley" fault has a displacement of some 75 feet. It would appear therefore that the displacement along the valley fault becomes greater to the south.

Only one of the veins on the 480-ft. level was observed to pass through the fault; this was No. 6 vein, which, as already stated, was followed for 10 feet northeast of the fault. The vein was not faulted. Elsewhere on the Chambers-

Ferland and Nipissing, the veins pass through this fault without any displacement so far as the writer has observed. This would appear to show that the veins are younger than the faults.

453-ft. Level.—This is a small level, only about 27 feet above the 480-ft. level. On account of caving, we were able to examine only a few feet in the vicinity of winze D. It was observed that the contact between the Keewatin and Cobalt series is 6 feet above the floor of the level.

425-ft. Level.—This is the most extensive level in the Chambers-Ferland mine. A concrete dam near vein No. 15 prevented an examination of the north part of the level. In this inaccessible part it was reported that fault No. 64 was met with and drifted on for 450 feet. No ore was reported in the fault, although a little calcite occurs here and there.

In the accessible portion of the workings the most northerly vein is No. 15, which is the eastward extension of vein No. 98 on the Nipissing, the most important branch of the great Meyer vein. Vein No. 15 has been stoped for about 80 feet east of the Nipissing boundary and has been drifted on for 120 feet farther east. Just east of the stope the vein splits into two branches, the south branch of which has 1 to 5 inches of smaltite and calcite, but contains little or no silver. Towards the east these two branches gradually pinch out until, on the east faces of the two drifts, the veins are mere cracks, an eighth of an inch or less, containing gouge-like material. Thus dies out the eastward extension of one of the greatest veins in the Cobalt area.

Vein No. 18 has been stoped for nearly 100 feet east of the fault shown on the plan. This fault is described below.

Vein No. 14, said to be the Nipissing vein No. 490, has also been stoped for nearly 100 feet east of this fault.

The fault referred to above has been drifted on for about 300 feet. It dips steeply eastward, in one place at an angle of 68°. All of the veins which we examined pass eastward through this fault. Vein No. 15 was stoped for a distance of 30 feet east of the fault, and veins Nos. 14 and 18 were, as previously stated, stoped about 100 feet east of it. We were not able to observe the relation between the fault and the veins; it is reported, however, that the veins were not faulted.

This fault may be the northward extension of the "valley" fault on the Nipissing; this we were not able to prove.

All the accessible part of the 425-ft. level consists of the Cobalt series.

350-ft. Level.—The north part of the level was not accessible. It was reported that fault No. 64 was met with and followed for over 400 feet. No silver was found in the fault, but a little nickel bloom occurred at the west end.

There are four calcite veins on the level, none of which were productive.

The long crosscut extending southwestward from No. 64 fault is entirely in finely bedded, slate-like greywacké of the Cobalt series. The greywacké dips southeastward at an angle of about 7° to 9°.

Winze D and crosscut extending east therefrom reveal an interesting structure in the Cobalt series. In the winze the bedding dips gently to the west, while, about 60 feet east of the winze, the bedding begins to dip southeastward at angles of 7° to 8° and continues this southeastward dip to the east end of the crosscut. Thus there is here an anticline in the sediments of the Cobalt series; or, if not an anticline, then the sediments follow the contour of a gentle hilltop in the underlying Keewatin. It is not known how far east this southeastward dip continues, but it is likely that, as the Cobalt lake fault is approached, the sediments will be found turned up and dipping again westward.

The part of the level which was examined is entirely in the Cobalt series.

275-ft. Level.—Vein No. 15 was met with at the north end of the level where it has been stoped for about 65 feet east of the Nipissing boundary. It is reported that high-grade ore was obtained. East of the stope about 40 feet, the vein splits. The north branch was followed for about 55 feet and found to pinch out to a mere crack; but the south branch was a strong vein, showing up to 4 inches of smaltite and calcite; it was followed for 120 feet. The east face of the drift still showed an inch of smaltite.

In winze D, there is a bed of slate-like greywacké about 49 feet thick; it was met with 14 feet below the 275-ft. level, and 12 feet above the 350-ft. The bedding of the greywacké dips gently westward.

Workings from No. 2 Shaft, Right of Way

The Chambers-Ferland mine obtained permission from the Right of Way mine to use the latter's No. 2 shaft. This shaft is conveniently located so that the Chambers-Ferland could operate its property immediately to the north of the Right of Way No. 2 shaft. There is no connection between these workings and those from No. 4 shaft.

Several small veins were worked in this part of the Chambers-Ferland mine; these veins strike nearly at right angles to the Cobalt lake fault.

There are three levels, the 410-ft., the 358-ft., and the 83-ft. Commencing with the lowest, these levels are described below.

410-ft. Level.—The level is reached by a winze from the 358-ft. level of the Right of Way. There are about a dozen small veins consisting mostly of pink calcite and a little smaltite. These veins all average less than an inch in width, although they are larger in places. Only one, No. 21, at the south end has been productive, and it was stated that it produced about 30,000 ounces of silver. The stope on this vein extends into the Nipissing, which also obtained some ore from the vein. The stope is below the 410-ft. level. Where the vein is still exposed in the back of the drift, it is seen to be a pink calcite vein up to 2 or 3 inches wide, but averaging much less.

Vein No. 23 shows about three-quarters of an inch of smaltite on the west face of the drift.

Vein No. 28 is at the north end of the level. It is only about a quarter of an inch wide at the west end, but at the east end is as wide as an inch and a half. At the east end, the wall rock is impregnated with native silver. The vein consists mostly of pink calcite with a little smaltite.

The Cobalt lake fault is at the south end of the workings, but is on the Right of Way property about 30 feet south of the boundary. The Keewatin is on the south side of the fault, and the Cobalt series on the north. The fault has been drifted on for 70 feet, and dips about 60° to the southward. The strike of the fault is a little unusual here, being a few degrees north of east. No cobalt bloom was noted in the fault, and only a few irregular stringers of calcite a few inches long here and there were observed.

The contact between the Keewatin and conglomerate north of the Cobalt lake fault occurs at the winze on the Right of Way property and, as far as could be determined, strikes a few degrees east of north. The dip of the bedding of the Cobalt series is about 10° to the west. There are two winzes at the north part of the workings, in the most northerly of which Keewatin was said to be encountered about 7 feet below the level, while in the other winze the Keewatin was said to be encountered about 10 feet below the level.

358-ft. Level.—There are only three small pink calcite veins on this level, none of which were productive.

At the north end of the level, what was considered to be the southeastward extension of vein No. 490 on the Nipissing was encountered. The location of this vein, which is small, is not shown on our plan of the 358-ft. level.

South of this vein, a vein known as No. 28 was explored in a raise to a height of about 81 feet above the 358-ft. level. The vein in this raise was small, and at the top was a mere crack. The first 14 feet of rock in the raise was said to be slate-like greywacké, finely bedded and similar to that on the level. On top of the slate it was stated there was a bed of quartzite 60 feet thick, above which is conglomerate to the top of the raise. A few feet of drifting was done on the vein at the top of the raise with no results. Most of this level is in a finely bedded, slate-like greywacké which dips at very gentle angles. At the south part it dips at about 10° northwestward, while at the north end it dips about 5° southward, forming a gentle basin. Ripple marks are common in this rock.

The Cobalt lake fault was encountered 100 feet north of the shaft and was followed by a drift for 200 feet; but all the work on the fault was done in the Right of Way property. The fault contains only a few short stringers of calcite.

At the point where the drift leaves the Cobalt lake fault, there are two or three fractures parallel to the lake fault and within some 10 feet of it. These fractures contain cobalt and nickel bloom.

83-ft. Level.—In the crosscut north of the Right of Way No. 2 shaft, the Cobalt lake fault was intersected. Just south of the fault there is a vein up to 2 inches in width, consisting of calcite and a little smaltite. No. 3 shaft of the Chambers-Ferland was sunk on this vein, but it was apparently of no economic importance.

Southeast of No. 2 shaft, there is a crosscut running into that part of the Chambers-Ferland which is south of La Rose. The Keewatin was encountered in this crosscut; resting directly on top of the Keewatin is a bed of slate-like greywacké of the Cobalt series with little or no conglomerate intervening.

Workings North of the Northeast Corner of O'Brien

These workings were practically inaccessible at the time of examination, but the plans are published on sheet No. 31a-14. Fault No. 64 had some work done on it, and a little high-grade ore was reported to have been found. The fault may be seen on the adjacent La Rose property in the face of the cliff, and in the tunnel on vein No. 10.

FOSTER

The Foster property, at the time of our examination in the autumn of 1920, was under lease to the Mining Corporation of Canada, Limited, and was being operated under the name of the Central Operating Company, Limited. The total output of silver from the property amounted to 815,346 ounces. The old company, the Foster Cobalt Mining Company, Limited, was capitalized at $1,000,000, of which $915,588 were issued. The par value of the shares was $1. The old company paid $45,000 in dividends.

Prior to the operations of the Mining Corporation, the property was under lease to Mr. C. L. Campbell who found a small though very rich ore-shoot in No. 6 vein.

The only known veins occur at the southeast end of the property. The vein-system is an unusually regular one, consisting of a number of parallel veins striking northwest, and a number of parallel veins striking northeast. An interesting feature of the veins which strike northwest is that two of them follow narrow bands of cherty rocks which may possibly belong to the Keewatin "iron formation." It is evident that the fractures in which these veins occur followed the line of weakness formed by the "iron formation." In the Cobalt camp other examples occur in which veins follow the strike of the Keewatin "iron formation", notably in the Buffalo and Hudson Bay mines.

The Cobalt series on the Foster is quite shallow at the south end where the veins occur. There is just a narrow fringe of this series along the southeast shore of Glen lake. Consequently, practically all of the mine workings are in the Keewatin series.

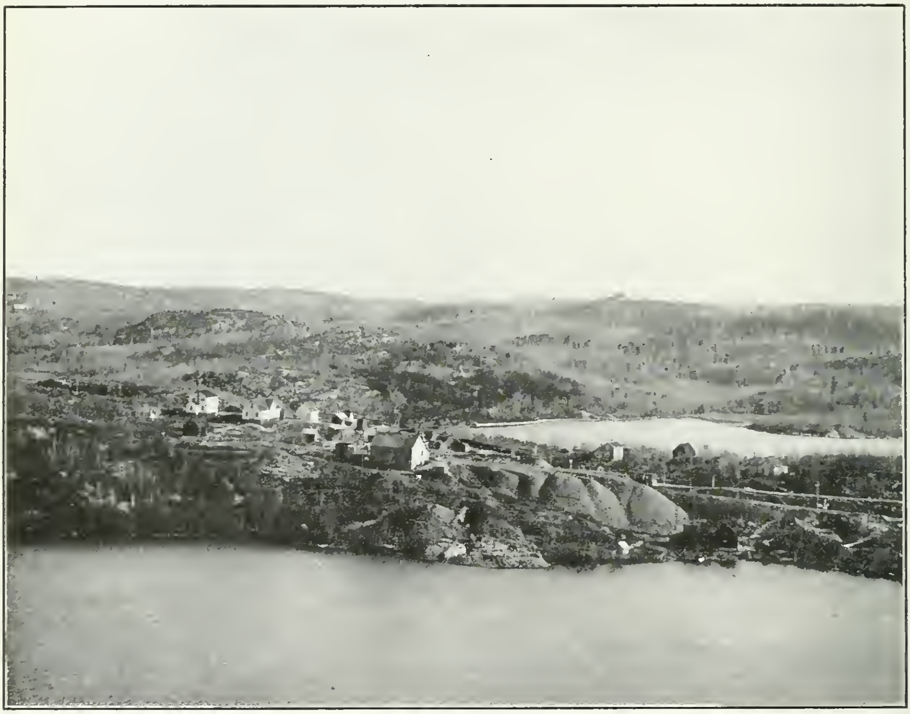


Fig. 35—Foster and Lawson mines; Glen lake in foreground, Giroux lake in background.

The rich ore-shoot found by Mr. C. L. Campbell occurred in the Keewatin, and was in vein No. 6 between the 40-ft. level (elevation 981.6 feet) and the 70-ft. level, in the vicinity of No. 6 shaft.

On the 40-ft. level, there is a fault dipping steeply northeastward. The writer was informed that in vein No. 23 no silver was found northeast of this fault, except a little on the surface. The fault, as in many other instances in Cobalt, appears to have had some influence in the deposition of the silver.

On the 210-ft. level, there is an exploratory crosscut and drift running almost entirely across the property in a northwestward direction. A vertical section along the north part of this crosscut is printed on the sheet showing the plans of the Foster mine. The north part of the crosscut follows about the bottom of the Nipissing diabase sill. In working out the contacts on this level we found a large block of slate-like greywacké imbedded in the diabase at the winze. The block has a length of over 125 feet. The occurrence of large inclusions in the Nipissing diabase is, curiously enough, quite uncommon in the Cobalt area. The two other conspicuous instances are at the Beaver and Violet mines.

The lowest level in the Foster, the 260-ft., is at the northwest corner of the property. It is reached by a winze at the north end of the long crosscut on the 210-ft. level. The 260-ft. level is of interest, as it shows there is a thickness of about 28 feet of the Cobalt series between the bottom of the Nipissing diabase sill and the underlying Keewatin.

PETERSON LAKE

Peterson Lake produced 744,343 ounces of silver. The property was not pumped out during the time of our examination of the Cobalt area. The plans of the underground workings are, however, shown on one of the plans in the pocket at the back of this report. Three vertical sections, illustrating the structure of the rocks, are shown on pages 168 and 169.

SILVER LEAF

The Silver Leaf is contiguous to and west of the Crown Reserve. The property produced 487,956 ounces of silver. It was leased to the Crown Reserve for a number of years, the lease expiring on October 15th, 1919.

The Carson vein, which produced 9,211,279 ounces of silver on the Crown Reserve, was a bitter disappointment on the Silver Leaf. The writer has not been able to ascertain how much silver it yielded in the Silver Leaf territory, but its yield was insignificant compared to that on the Crown Reserve.

The writer has not been able to obtain much information about the property and, moreover, it was not being worked during our examination. The following notes may be put on record.

In 1914, the most important development since the property was under lease to the Crown Reserve took place on the 75-ft. level, 500 feet west of No. 1 shaft, where a vein one inch wide was encountered assaying 1,000 ounces of silver per ton.

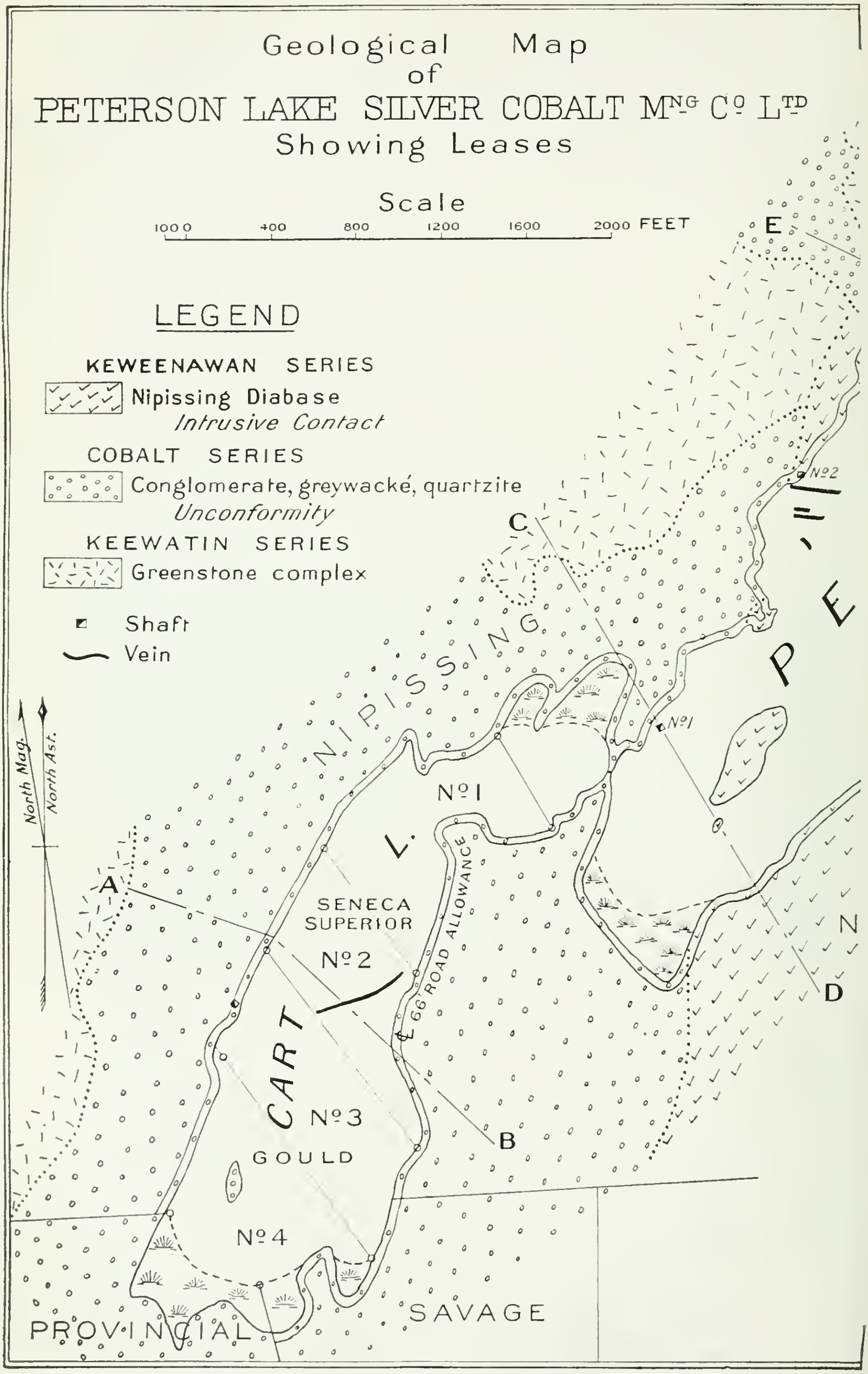
In 1915 the property gave a profit of $16,140.41 over all expenses, and produced 84,000 ounces of silver. In 1918, one ton of high-grade and 2,216 tons of mill-rock were raised and shipped. In 1919, the net revenue was $1,963.44, of which $1,276.22 was due to the Crown Reserve.[1]

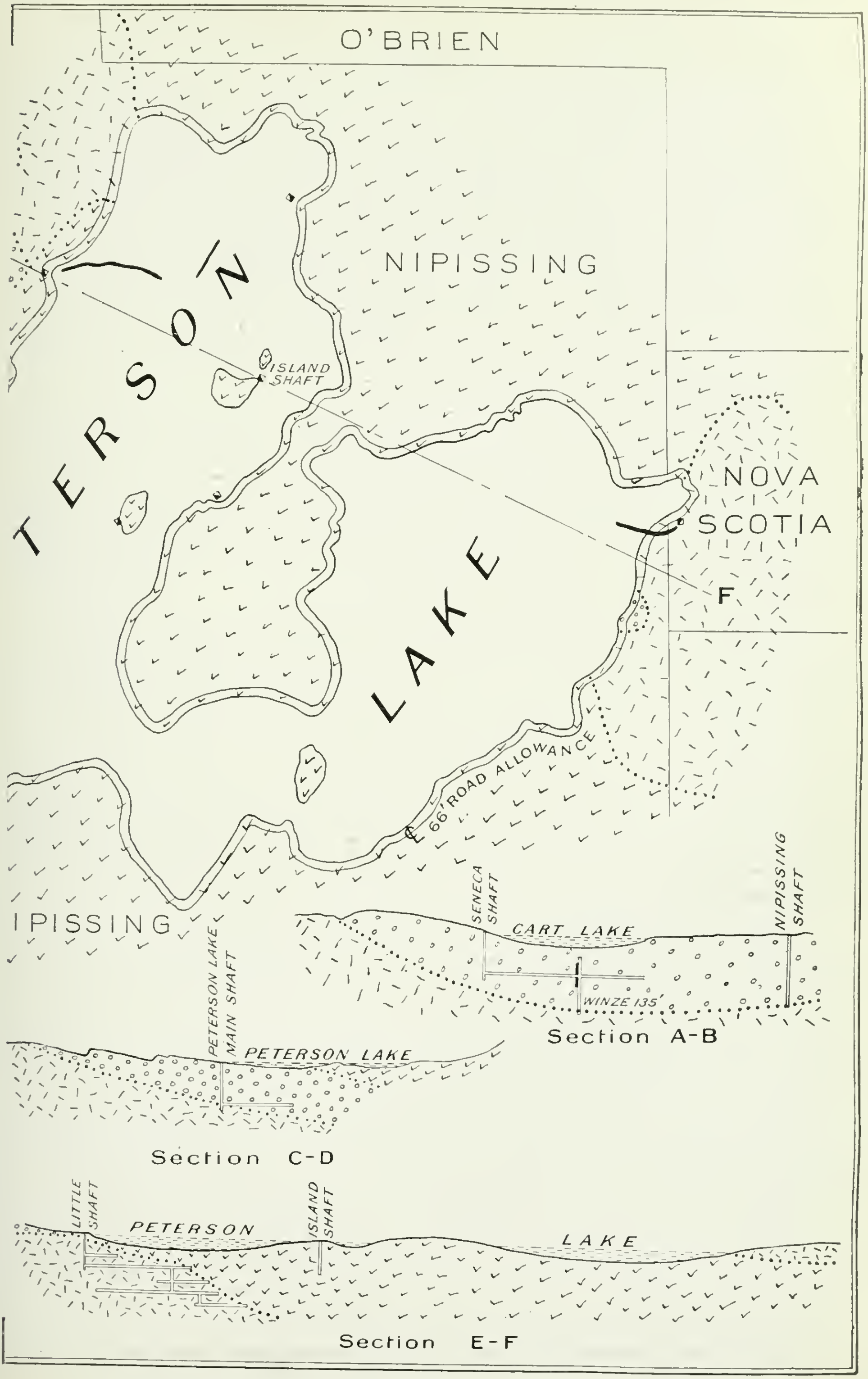
The lowest level of the Silver Leaf is the 300-ft., which is the westward extension of the 300-ft. level on the Crown Reserve north of Kerr lake. Work was done on the extension of the North vein into the Silver Leaf property, and some ore was mined.

The 200-ft. level of the Silver Leaf is all in Keewatin, and consists of a long westward crosscut, which was not productive of results. The 130-ft. level was not examined. The 125-ft. level is a small one which is reached from the west end of the 75-ft. level; it was not examined, nor was the 100-ft. level. The 75-ft. level intersected the Nipissing diabase in three crosscuts, in the most easterly of which the contact of the diabase dips 70° to the north, an unusually steep dip. The bed of slate-like greywacké on the 75-ft. level dips at 10° to 20° to the north, but at the shaft near the east boundary it is steeper, apparently owing to a fault. The 50-ft. level of the Silver Leaf is about the same elevation as the 50-ft. level of Crown Reserve. The Carson vein splits into two branches before entering the Silver Leaf, and these two branches extend a short distance into the Silver Leaf.

---

[1] Annual Reports of the Crown Reserve Mining Company, for the years 1914, 1915, 1918, 1919.


Geological Map
of
PETERSON LAKE SILVER COBALT M^NG C^O L^TD
Showing Leases
Scale
100 0 400 800 1200 1600 2000 FEET
LEGEND
KEWEENAWAN SERIES
Nipissing Diabase
Intrusive Contact
COBALT SERIES
Conglomerate, greywacké, quartzite
Unconformity
KEEWATIN SERIES
Greenstone complex
Shaft
Vein
North Mag.
North Ast.
E
C
NIPISSING
No 2
No 1
PE
A
N
No 1
L.
SENECA
SUPERIOR
No 2
66' ROAD ALLOWANCE
D
CART
No 3
B
GOULD
No 4
SAVAGE
PROVINCIAL


O'BRIEN
NIPISSING
TERSON
LAKE
ISLAND SHAFT
NOVA SCOTIA
F
℄ 66' ROAD ALLOWANCE
IPISSING
SENECA SHAFT
CART LAKE
NIPISSING SHAFT
WINZE 135'
Section A-B
PETERSON LAKE MAIN SHAFT
PETERSON LAKE
Section C-D
LITTLE SHAFT
PETERSON
ISLAND SHAFT
LAKE
Section E-F

COLONIAL

The Colonial mine produced 388,681 ounces of silver to the end of the year 1921.

The writer did not have an opportunity of examining the upper workings, or those along the top of the Nipissing diabase sill. These old workings were operated largely in the earlier days of the camp, and the silver production to the end of the year 1921 has been obtained wholly from them.

More recently, a new shaft has been sunk. This shaft was completed in the spring of 1923, and on May 4th of that year the writer examined it. The location of the new shaft is shown on the plan of the Colonial workings; it was begun in the Nipissing diabase almost at the top of the sill. At a depth of approximately 960 feet below the collar, the bottom of the Nipissing diabase sill was met with. The rock below the sill is Keewatin basalt.

Near the new shaft, about 30 feet above the bottom of the diabase sill, a vein was met with in the diabase and had been followed for a short distance at the time of our examination. On the northwest face of this vein native silver in thin leaves was impregnated in the diabase, giving what was reported to be mill-rock. The vein really consisted of about a dozen calcite stringers across a width of about three feet. These calcite stringers were from a quarter to half an inch wide. One of these was an inch wide and consisted of pink calcite, together with some smaltite and a little native silver.

It was reported to the writer by Robt. A. Bryce that in subsequent operations on this vein, some high-grade silver ore was discovered.

In the fall of 1923 and the winter of 1924, some mill-rock of good grade was being shipped.

DRUMMOND FRACTION

The Drummond Fraction is at the east end of Kerr lake and comprises that part of the Drummond which is under the water of Kerr lake. There are about seven acres in the claim. The property is jointly owned by the Crown Reserve and Kerr Lake mining companies, having been purchased by these companies in 1913.

The property has produced 356,643 ounces of silver.

At the time of our examination the mine was not in operation. The following information has been summarized from the reports of the inspectors of mines for the Province of Ontario.[1]

In 1913, after the lake was lowered, a high-grade vein averaging 2 inches in width was opened up on the surface for 60 feet in length. The vein was worked from the Wright shaft on the Drummond property by a crosscut which was driven from this shaft at the 100-ft. level.

In 1914, the production was derived mostly from the No. 1 vein. The output for the year was 134,256 ounces of silver, of which 95,771 ounces was from mill-rock, and 38,485 from high-grade ore.

During 1916 the property produced 40,450 ounces.

In 1917, the production amounted to 67,112 ounces, taken chiefly from a smaltite vein which is said to be the easterly extension of the Fleming vein, and also from a vein which is the westerly extension of the Comet (Drummond) vein.

Work was discontinued on January 31st, 1917.

---

[1] Annual Reports, Ont. Bur. Mines, for years 1913, 1914, 1916, 1917.

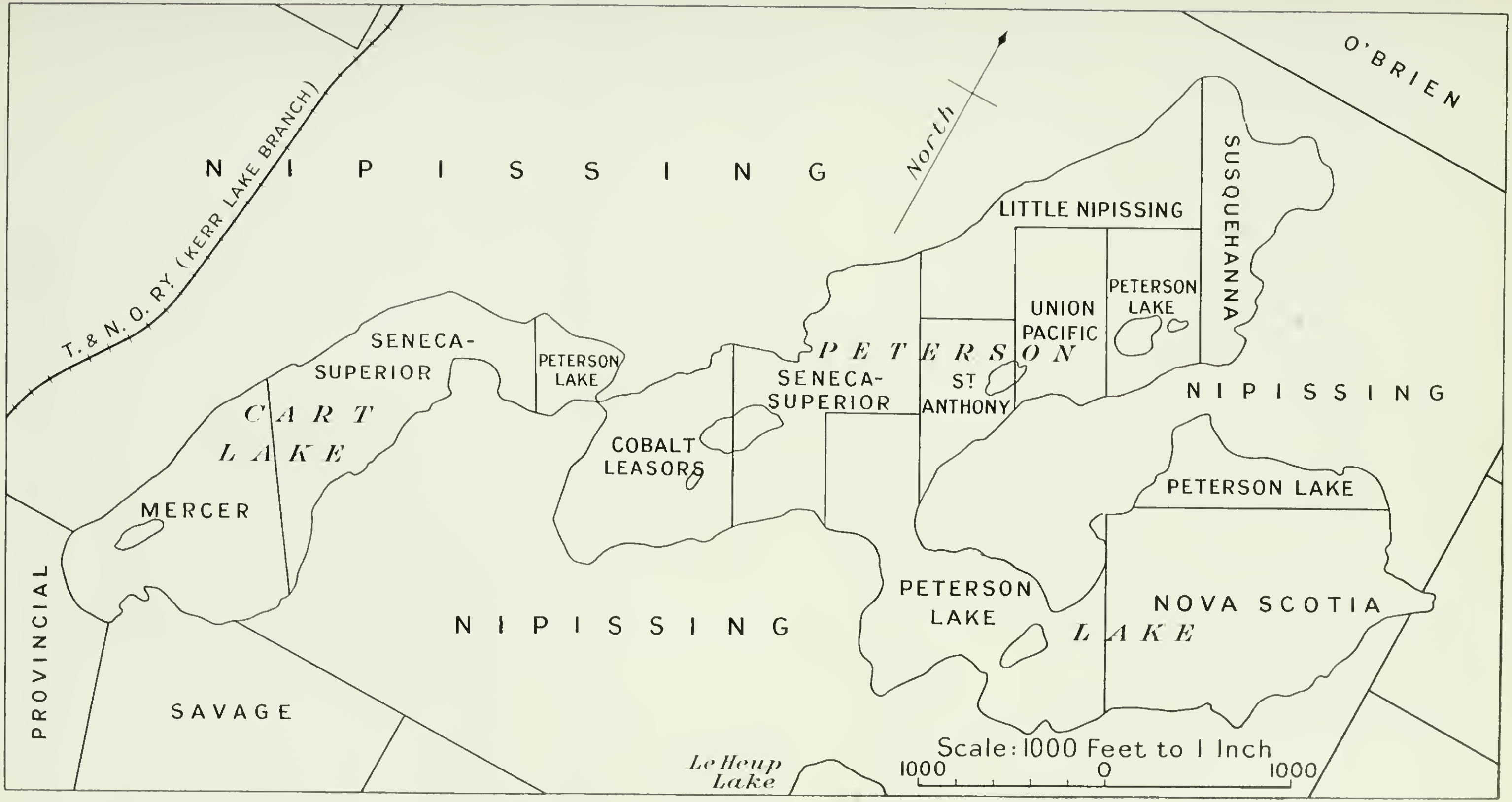


Fig. 36—Plan showing location of leases which were granted from time to time by the Peterson Lake Mining Company. These leases have since been surrendered or cancelled. The Mining Corporation of Canada, Limited, leased Cart and Peterson lakes in 1922.

BAILEY

At the time of examination in the autumn of 1920, the property was being worked by the Bailey Silver Mines, Limited.

The mine has produced 286,600 ounces of silver. The extent of the mine workings is not great, as shown on the plans of the mine. The vein-system on the property consists of an extension of the Penn-Canadian vein-system.

The structure of the rocks is about similar to that at the Penn-Canadian, as will be seen from the vertical section facing page 40. An interesting feature of the structure, however, is the manner in which the conglomerate of the Cobalt series pinches out about 400 feet west of the shaft in the long crosscut, resulting in the bed of slate-like greywacké resting directly on the Keewatin. This structure shows that there is a depression in the Keewatin which was partly filled with conglomerate of the Cobalt series. After the conglomerate was laid down, conditions of deposition changed and a bed of slate-like greywacké was deposited. Above the depression in the Keewatin, the slate-like greywacké was deposited on the conglomerate, but, along the side of the depression where no conglomerate had been laid down, the slate-like greywacké was laid down on the Keewatin floor. Similar conditions of erosion and deposition occur under Cobalt and Cart lakes.

Near the bottom of the Nipissing diabase sill, there is an almost horizontal fault showing 4 to 6 inches of fault breccia. It was stated that no ore occurs in the diabase below this fault.

PROVINCIAL

The Cobalt Provincial Mining Company, Limited, has a capital of $1,500,000. The property has produced 245,832 ounces of silver.

The mine was worked from two shafts, one at the northwest corner of the property and the other at the east side of the property. The workings at the northwest corner of the property were in connection with the discovery of a vein made by a geological survey party of the Ontario Bureau of Mines in the year 1906. The workings at the east side are adjacent to the Savage workings, the Provincial No. 2 shaft being about 43 feet from the Savage boundary. The vein worked from No. 2 shaft is the westward extension of No. 2 vein of the Savage.

The workings at the northwest corner of the Provincial mine were flooded at the time of the examination in August, 1921, so that an examination could not be made.

Part of the workings at the east side were being kept dewatered to within a few feet below the 175-ft. level. The No. 2 shaft in this part of the mine is reported to be 350 feet deep, and the levels are at the following elevations below the collar of the shaft, namely, 100-ft., 175-ft., 217-ft., 300-ft., and 350-ft. The shaft was sunk on a calcite vein, and it is reported that the vein continued vertically to the bottom of the shaft. When the vein passed into a 20-ft. bed of slate-like greywacké below the 175-ft. level, it became irregular and patchy. The bottom 100 feet of the vein was reported to consist of pure smaltite, 8 inches wide in places, assaying 2 to 40 ounces of silver. We were able to examine the vein in the shaft from about the surface down to the 175-ft. level, and found it to be a strong calcite vein 1 to 3 or more inches wide.

The Cobalt series has a thickness of approximately 350 feet in the No. 2 shaft, the contact between the Keewatin and Cobalt series having been found at about that depth in the shaft by Mr. John Redington.[1]

---

[1] Private communication from Mr. John Redington.

The rocks in the shaft consist of conglomerate and greywacké, with the exception of two beds of slate-like greywacké, one of which is about 4 feet thick just above the 175-ft. level, and the other about 20 to 25 feet thick at about the 217-ft. level.

The Cobalt series rests in a deep erosion valley carved in the old Keewatin. This Keewatin valley strikes northeastward along the bed of Cart lake. The eastern side of the valley is extraordinarily steep, dipping as it does to the northwestward at an angle of about 50° or more (Fig. 37). The bottom of the valley was first filled with conglomerate, upon which a bed of slate-like greywacké was later deposited. The sediments were laid down in such a way that the conglomerate filled the bottom of the valley, and the slate-like greywacké was deposited directly on top of the Keewatin on the upper sides of the valley, but on top of the conglomerate which filled the bottom of the valley (Fig. 37).

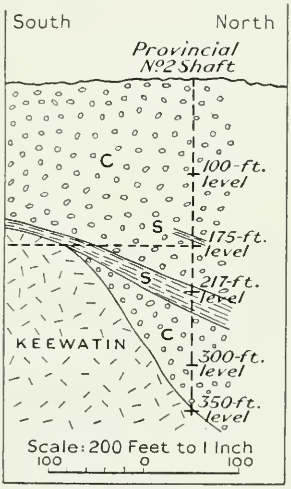


Fig. 37—Vertical section through the Provincial mine showing deep basin in Keewatin; a bed of slate-like greywacké rests directly on the Keewatin on the side of the basin, and on conglomerate in the middle of the basin.
S—Slate-like greywacké. C—Conglomerate.

The property was examined by Mr. James Hill in 1921, and the writer also spent part of a day in the same year in company with Mr. John Redington. A description of the two accessible levels, based on information furnished by James Hill and John Redington, is given below.

175-ft. Level, No. 2 Shaft.—The vein on this level is the westward extension of No. 2 vein on the Savage. It has been stoped for 160 feet. There is a parallel vein which has been stoped for 35 feet. The larger stope connects with the stope on the Savage. The two veins unite a few feet west of the Provincial shaft. A calcite stringer crosses the vein about 40 feet west of the shaft, and at this intersection the richest ore was said to have been obtained.

About 165 feet southwest of the shaft, the vein encountered a minor fault showing an inch or two of fault breccia and dipping about 65° eastward. To the west of this fault the vein is very small, consisting of a crack with an eighth of an inch of calcite. About 40 feet west of the fault the vein pinches out.

All of the level consists of the Cobalt series, except the south part of a crosscut running south of the shaft. In this crosscut, about 120 feet south of the shaft, a bed of slate-like greywacké a few feet thick rests directly on Keewatin. The slate-like greywacké has ripple marks. The crosscut was driven in Keewatin for some distance, as shown on the plan. At the south end of the crosscut, there is an inclined raise showing the steep dip of the Keewatin floor.

The bed of slate-like greywacké was also met with in the shaft at the 217-ft. level where it is much thicker; it was also encountered at the southwest end of the long crosscut which extends southwestward from the No. 2 shaft on the 175-ft. level.

A long crosscut extends northwest from No. 2 shaft to the northwest part of the property. This crosscut was inaccessible owing to a dam near the No. 2 shaft; it was stated, however, that the crosscut was wholly in the Cobalt series, except at the north end where the Keewatin was encountered.

100-ft. Level, No. 2 Shaft.—The vein is stoped westward from the shaft for 70 feet; in the west face the vein varies in width from one to four inches. The ore does not extend to the surface. The level is all Cobalt series.

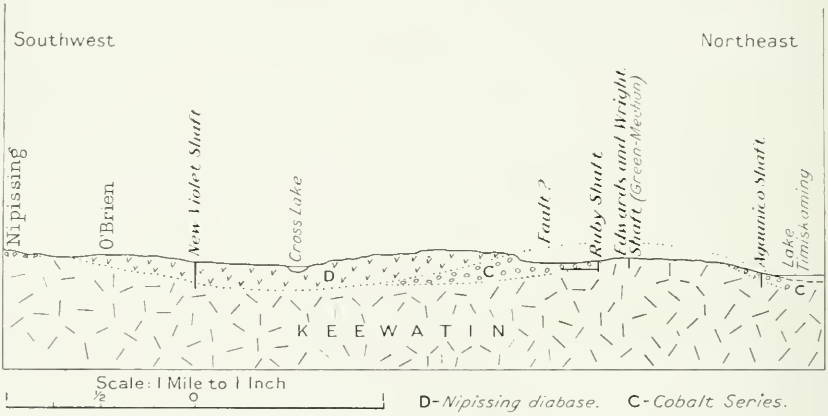


Fig. 38—Vertical section showing relation between the Nipissing diabase sill and underlying rocks at Nipissing, O'Brien, Violet, Ruby, Edwards and Wright (Green-Meehan), and Agaunico. Since this vertical section was drawn, subsequent operations at the Ruby, early in 1924, proved the existence of a major fault at the spot marked "Fault?". Vertical scale slightly exaggerated.

EDWARDS AND WRIGHT (GREEN-MEEHAN AND RED ROCK)

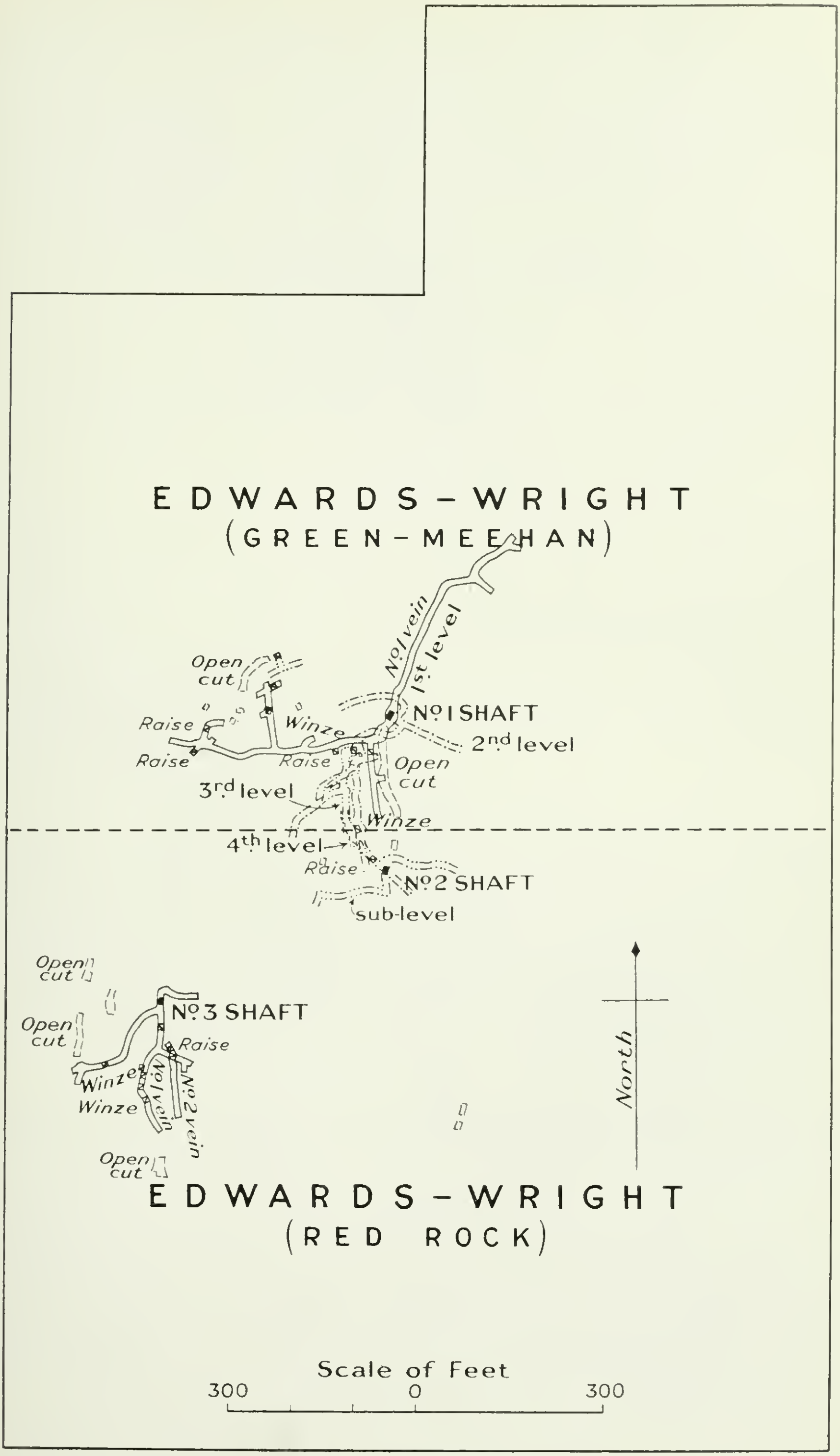
Edwards and Wright, Limited, was incorporated on January 30th, 1918, with a capital of $100,000. The company worked the old Green-Meehan and Red Rock properties for a number of years.

To Major Ward Wright, who operated the Green-Meehan in recent years, belongs the credit for keeping alive interest in this section of the Cobalt silver area.

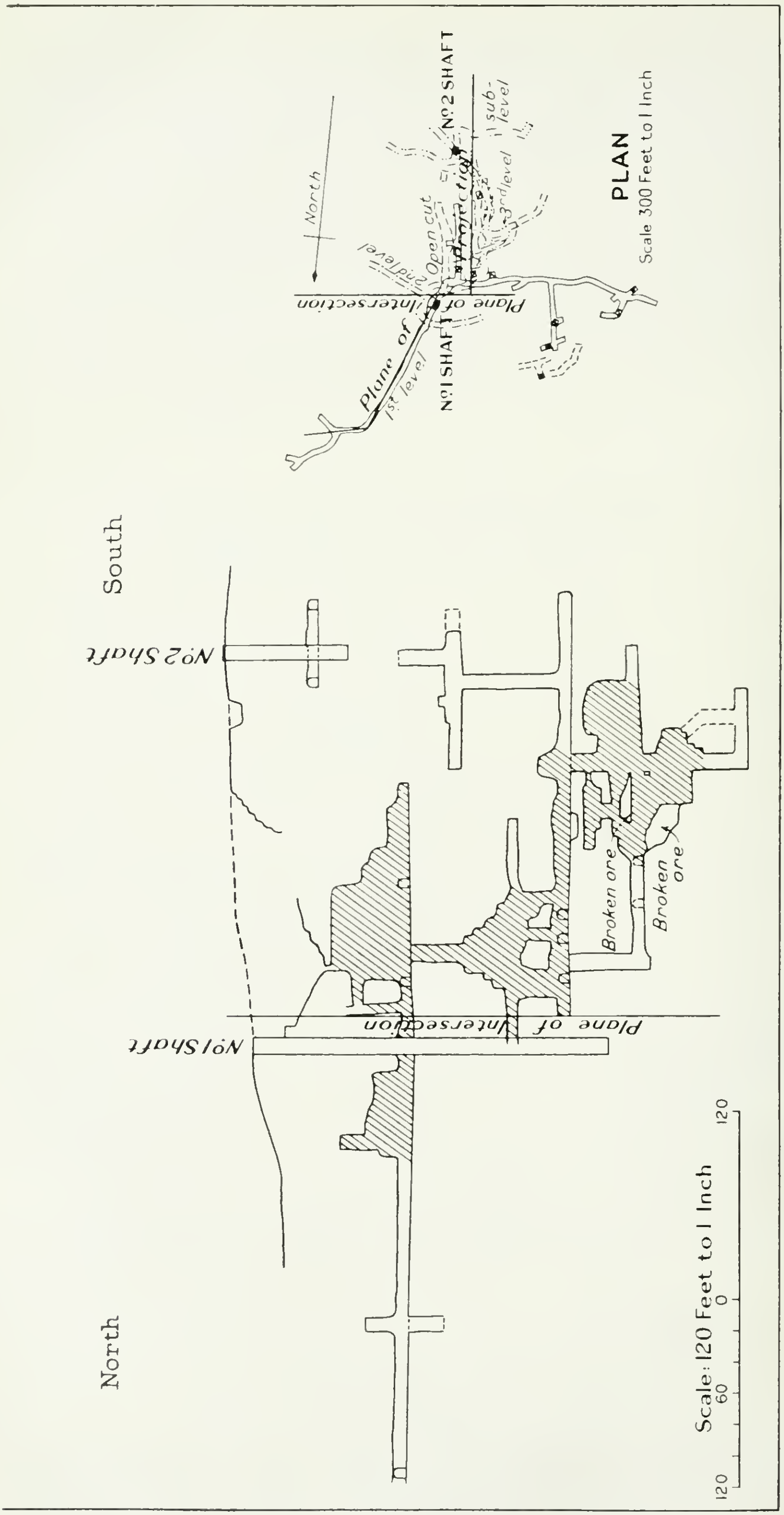
The Green-Meehan has produced 223,629 ounces of silver. There are a number of veins on the property, chief of which is the No. 1 vein on which most of the work has been done. Vein No. 9 also produced some ore from an open pit. The veins are all in Keewatin rocks.

A shaft has been sunk on the No. 1 vein to a depth of 200 feet with levels and sub-levels. The No. 1 vein is a strong calcite one in which half a dozen small ore-shoots have been discovered. The vein strikes about north and south and dips at an angle of about 75° westward. The trend of the ore-shoots is 35° southward.

There are a number of minor faults in the workings, one of which dips at an angle of about 35° to the south.



Plan showing mine workings of Edwards-Wright (Green-Meehan and Red Rock Mines)



Stope section on Edwards-Wright (Green-Meehan).

The general relationships of the rocks at the Green-Meehan to the rocks in the main productive area in Cobalt, are shown in the vertical section (Fig. 38). At the south end of the Red Rock the Nipissing diabase occurs; it rests on top of the Keewatin and dips eastward towards Lake Timiskaming and westward towards Cobalt, forming a gentle dome. The No. 1 vein on the Green-Meehan occurred below the dome. Of course that part of the diabase above the No. 1 vein has long since been eroded. Possibly the vein extended upwards into the diabase and may have contained rich shoots.

The Red Rock is contiguous to the Green-Meehan on the south. The rock consists mostly of Keewatin basalt; but there are a few patches of conglomerate of the Cobalt series on the west side of the property. These conglomerate patches are only some 10 or 15 feet thick. There are three shafts on the property 35, 75, and 110 feet deep. A number of calcite veins were found, characterized by the presence of copper pyrites.

Some of the veins on the Green-Meehan, Red Rock, and Ruby are characterized by the presence of unusual quantities of copper pyrites.

LITTLE NIPISSING SILVER MINE

The Little Nipissing property at Short lake is south of the Princess mine. The plans of the mine levels are shown on sheet No. 31a-13. Considerable exploration work was done on the property by the Mining Corporation, and while some patches of ore were found in the Cobalt lake fault, the results were not sufficiently encouraging, and operations ceased in the autumn of 1917.[1]

The Little Nipissing at one time held a lease of part of the northwest corner of Peterson lake (Fig. 36). This area produced 83,108 ounces of silver. The lease was later surrendered.

MERCER

Mr. W. E. Segsworth very kindly furnished the Ontario Department of Mines with the following information regarding the Gould Consolidated or Mercer mine, which is immediately southwest of the Seneca-Superior.

> The adjoining lease to the southwest was operated successively by the Gould Consolidated and Mercer Mining Companies. As previously indicated, the southwest end of the Worth ore body extended into this property 50 to 60 feet. From the Worth vein the Gould Consolidated produced 60,220.8 ounces of silver and the Mercer 81,998.41 ounces, or 142,219.24 ounces of silver in all. This, added to the production from the Seneca, gave a total production of 5,781,312 ounces from the Worth vein.

It may be added that in 1922 the Mining Corporation of Canada, Limited, leased Peterson and Cart lakes, pumped out the Seneca workings, began stoping the low-grade ore in the winze, and commenced exploration for further ore bodies.

ADANAC

The Adanac Silver Mines, Limited, operated claims in the southeast corner of Coleman township contiguous on the west to the Temiskaming mine. The company was incorporated on May 15th, 1915, with a capital of $2,500,000, and acquired claims formerly known as the Pan-Silver and Calumet. No large orebodies have been discovered, but some small shoots of high-grade silver ore were met with and some shipments of mill-rock were made. The company produced 28,057 ounces of silver.

---

[1] Fourth Annual Report, Mining Corporation of Canada, Limited, for year 1917, p. 23.

At the time of examination, in July, 1921, the only accessible shaft was the Patterson, at the southeast corner of the workings. From this shaft there are seven levels which are 100, 200, 267, 300, 310, 321, and 400 feet below the collar of the shaft. The 310-ft. and the 267-ft. levels are reached by way of winzes.

James Hill examined the 100-ft., 200-ft., 300-ft., and 310-ft. levels in 1921 for the Ontario Department of Mines; at that time the water was a few feet below the 310-ft. level. The information given below concerning these levels is based on Mr. Hill's notes.

310-ft. Level.—The workings in the south half of the level are in Keewatin basalt. In the long drift running northward, the Nipissing diabase was met with dipping 18° to the southward. This long drift follows for 1,050 feet a small calcite vein from a quarter of an inch to two inches wide. Near the south end of the vein, where it branches, there is a stope about 115 feet long and 15 to 20 feet high.

300-ft. Level.—This level is all in Keewatin which is cut in places by lamprophyre in the vicinity of the shaft. A calcite vein about an inch wide occurs in the drift in which the winze has been sunk. There are no stopes on this level.

200-ft. Level.—The level is also in Keewatin rocks cut by lamprophyre dikes. East of the shaft there is a small stope 16 feet long and 15 feet high; the vein contains a little smaltite and niccolite.

100-ft. Level.—This level, which is a short one, is in Keewatin rocks. About 90 feet west of the shaft there is a vein of quartz eight feet wide.

LUMSDEN

At the time of examination, in October, 1920, the Lumsden mine was being operated by the Camburn Silver Mines, Limited, Major J. H. Rattray in charge. The Lumsden mine has produced 21,088 ounces of silver, which was obtained largely from the Keewatin.

The shaft was sunk in Keewatin and encountered the Nipissing diabase at a depth of about 290 feet.

The main vein-system strikes a little east of north and occurs a few feet east of the shaft. There are also two intersecting veins near the southeast end of the long crosscut on the 300-ft. level; and there is a vein called the "Vimy Ridge" on the 250-ft. level.

300-ft. Level.—The station at the shaft is in Nipissing diabase; about 50 feet south of the shaft the Keewatin was met with; the long southeastward crosscut is entirely in Keewatin rocks.

The vein-system a few feet east of the shaft consists of 3 or 4 parallel veins which split at a point about 100 feet south of the shaft. Some of these veins contain quartz.

Near the end of the long crosscut at the southeast end of the property, there are three veins at the junction of which a winze 20 feet deep had been sunk. On October 28th, 1920, the winze was 20 feet deep. A small patch of high-grade silver ore was reported to have been met with at the intersection of these veins.

250-ft. Level.—A few feet east of the shaft there is a quartz vein, about 6 inches wide, containing some calcite.

About 235 feet east of the shaft, a vein called the "Vimy Ridge" was met with and drifted on for over 200 feet; it was found to be a strong though irregular vein. About 90 feet east of the "Vimy Ridge" vein, the top of the Nipissing diabase sill was met with dipping southwestward about 22°. The crosscut was continued eastward into the Prince as far as its east boundary, and the rock was found to consist of Nipissing diabase. About 100 feet west of the east boundary of the Prince, there is a dike of fine-grained basalt cutting the Nipissing diabase. This dike is 12 or 15 inches wide and strikes 10° or 20° east of south. It resembles the small basalt dike on the 383-ft. and 499-ft. levels of the Temiskaming mine, and may be the northwest extension of the Temiskaming dike.

225-ft. Level.—The main vein on this level consists of a quartz vein 2 to 12 inches wide. A calcite vein follows this quartz vein. In some places the calcite vein is in the quartz vein; in other places it follows the wall of the quartz vein, and in still other places it may be 1 or 2 feet from the quartz vein. About 85 feet south of the Nipissing diabase, the quartz vein enters the wall of the drift and is not seen again. The calcite vein continues north to the diabase, where it splits into half a dozen calcite veins less than an inch in width. Native silver occurs in the quartz vein and in the calcite.

ROCHESTER

The Rochester mine was flooded at the time of examination. It produced 13,459 ounces of silver.

The plans of the levels are shown on a map in the pocket at the back of the report.

RUBY

The Ruby produced 8,702 ounces of silver to the end of the year 1922. During the years 1922 and 1923 it was under option to the Coniagas Mines, Limited. This company put down three diamond-drill holes. In the No. 1 hole, a four-inch vein of much promise was discovered; the vein contained mostly calcite, together with a little smaltite and copper pyrites. A sample of the vein in the core was found to assay 375 ounces of silver per ton.

The Ruby property is almost entirely covered with drift, and this diamond-drilling was done in the heavily-covered portions. In the drill hole which discovered the calcite vein, the drift was found to be about 50 feet deep, and, much to the surprise of every one, the Cobalt series was found to be about 160 feet deep.

The Coniagas management established a level at 150 feet in the shaft at the east side of the Ruby property and ran a crosscut about 1,000 feet westward. The vein which was cut in the diamond-drill hole was intersected in this long crosscut. Other veins were also found at the west end of the crosscut. These calcite veins contained native silver, ruby silver, and smaltite. In the summer of 1923 and early in 1924, they were being explored by the Coniagas management. A shoot of cobalt ore, 150 feet long and five or six inches wide, carrying small patches of native silver, was discovered.

The long crosscut referred to in the above paragraph was in Keewatin basalt for 446 feet west of the shaft, where the Cobalt series was met with. The Cobalt series consisted of coarse greywacké and fine conglomerate. One pink granite boulder 3 or 4 feet long was noted in the conglomerate, but the latter rock is for the most part made up of small pebbles.

Prior to the time when the Coniagas mine obtained an option on the property, a little work had already been done in some veins at the shaft. It was found that the conglomerate of the Cobalt series had a thickness of but 15 feet in the shaft, below which was the Keewatin. These workings had a depth of about

100 feet. Some shipments of good mill-rock had been made from a winze which was sunk from the 65-ft. level of the shaft. This ore was all obtained from the Keewatin in an irregular calcite vein; some of the silver was in the wall-rock.

On the surface, just southeast of the shaft, a calcite vein about an inch wide containing some smaltite was encountered. This vein may be seen at the present time in a shallow trench.

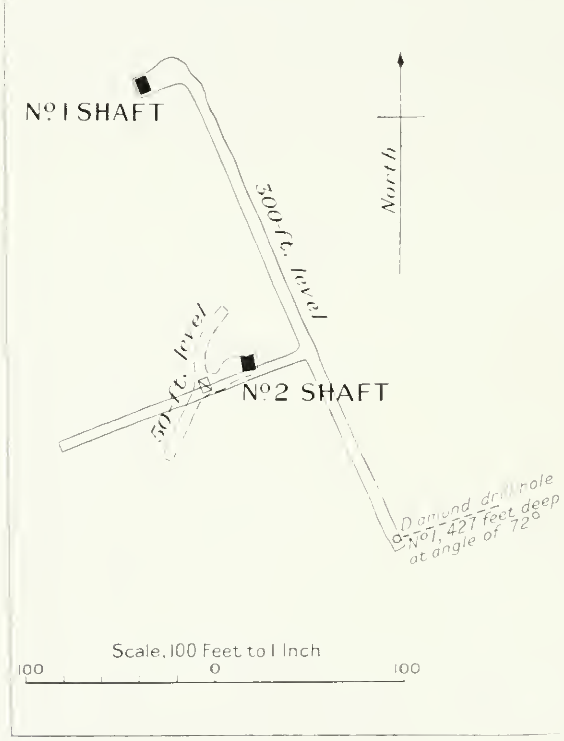

No. 1 SHAFT
300 ft. level
North
50 ft. level
No. 2 SHAFT
Diamond drill hole No. 1, 427 feet deep at angle of 72°
Scale, 100 Feet to 1 Inch
100
0
100

Fig. 39—Plan showing workings in North Cobalt mine, the southwest quarter of the north half of lot eleven, in the second concession, Bucke township.

NORTH COBALT MINE

The North Cobalt property, consisting of 40 acres, is located on the western outskirts of the town of North Cobalt. The claim is the southwest quarter of the north half of lot eleven, in the second concession of the township of Bucke.

The workings are shown on the plan (Fig. 39). They were not accessible during the time of our examination. Through the courtesy of the Mining Corporation of Canada, the writer was informed that the No. 1 shaft was sunk in Nipissing diabase to a depth of 300 feet. From the south end of the main crosscut, which is in Nipissing diabase, a diamond-drill hole was put down 427 feet at an angle of 72° to the eastward. The hole is reported to be entirely in Nipissing diabase.

The workings and drill hole thus show that the Nipissing diabase has a thickness of at least 700 feet in this area.

GENESEE

The Genesee property is located in Bucke township immediately to the north of the Chambers-Ferland (Fig. 40). A little high-grade ore has been encountered on the 350-ft. level, and about 800 bags of ore obtained up to January, 1924.

The property was examined on the 5th and 6th of May, 1923, but the lowest level, the 500-ft., was not accessible at that time. The Ontario Department of Mines is indebted to Mr. L. F. Steenman for the geological details of the 500-ft. level, and also for the plans of the three levels (Fig. 40) and the vertical shaft section (Fig. 41) showing the rocks in the shaft.

According to Mr. Steenman, the contact between the Cobalt series and the Keewatin occurs in the shaft 526 feet below the collar. There are few places in Cobalt where the Cobalt series has such a great thickness. The collar of the shaft is, according to the management's survey, 72 feet below the collar of No. 4 shaft of the Chambers-Ferland.

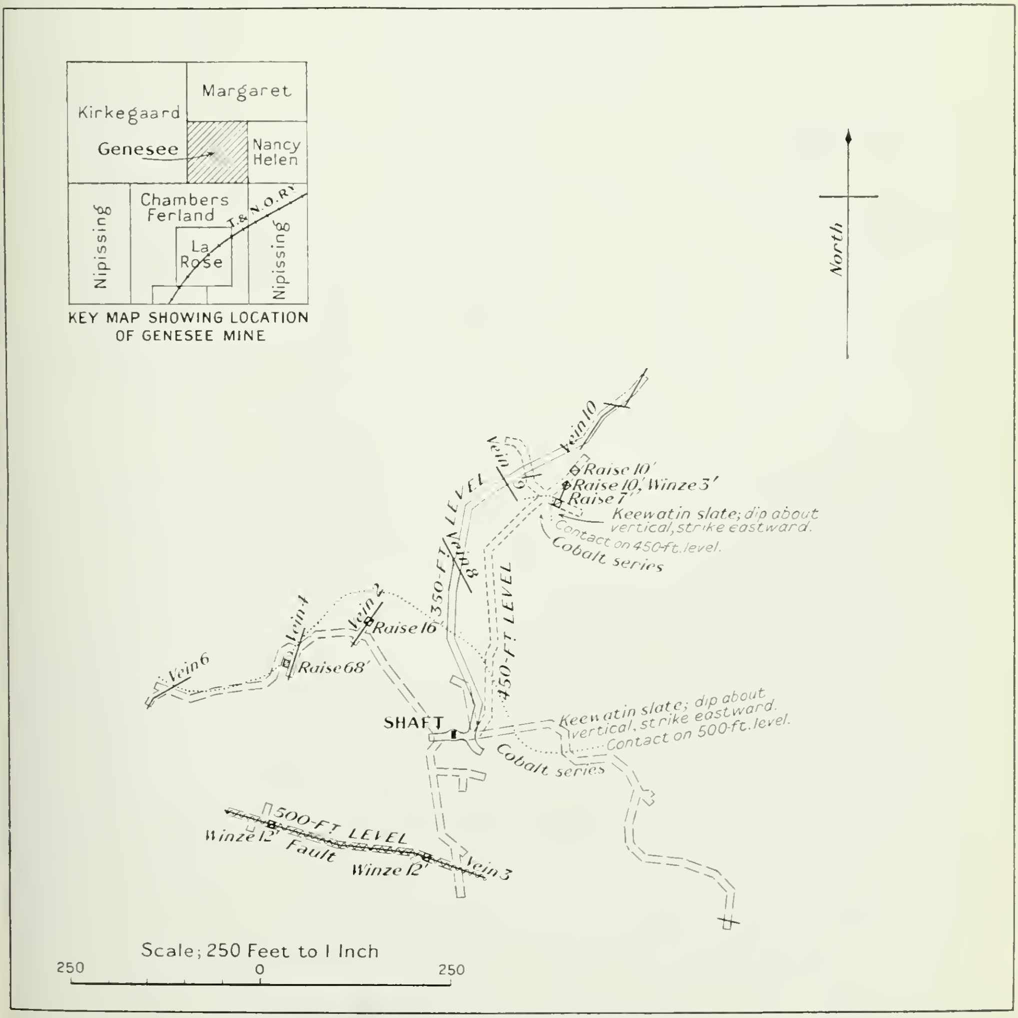


Fig. 40—Plan of Genesee levels, furnished by Mr. L. F. Steenman.

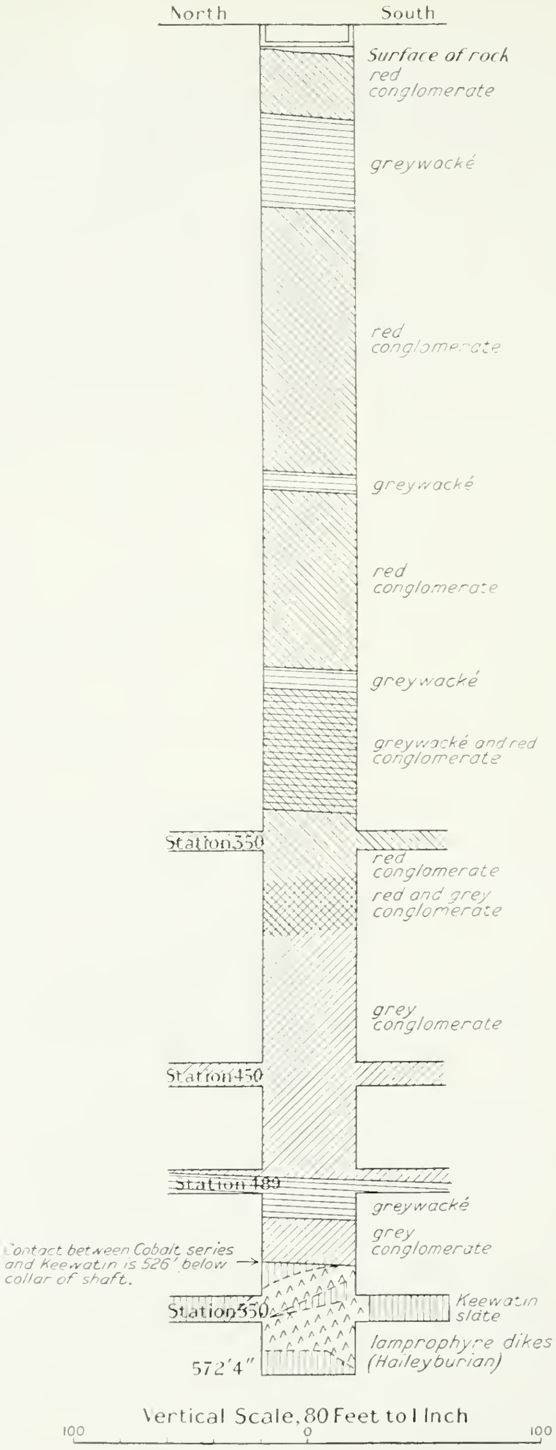


Fig. 41—Section by L. F. Steenman, showing rocks in Genesee shaft. The Cobalt series has a depth of 526 feet.

Beginning with the bottom level the following notes may be put on record.

500-ft. Level.—As stated above, this level was not accessible at the time of our examination, and the Department is indebted to Mr. Steenman for the following information. The Keewatin consists of a grey slate, dipping about vertically and striking eastward; samples of this rock may be seen on the dump. The slate in these samples from the dump is cut by mica-lamprophyre. It is stated that a few pebbles were found in the slate. Four veins were encountered, namely, Nos. 2, 3, 4, and 6. Vein No. 3 is reported to occur in a major fault, and a little silver is said to have been found in it.

450-ft. Level.—At the north end of the level, grey Keewatin slate was met with in three crosscuts (Fig. 40). The slate dips almost vertically and strikes eastward; it resembles the Keewatin slate in the deep bay of Sasaginaga lake just west of the Trethewey mine. The contact between the slate and Cobalt series is sharp and knife-like.

At the north end of the workings a small vein, No. 10, less than an inch in width, was met with. A sample of the mineral from this vein was submitted to W. K. McNeill, Provincial Assayer, and found to be cobaltite. This vein was met with in the workings just about at the contact between the Keewatin and Cobalt series.

350-ft. Level.—This level is all in the Cobalt series. Five veins were discovered, Nos. 8, 9, 10, 11, and 12. Vein No. 10 is about three-quarters of an inch in width, consisting of pink calcite; a little high-grade silver ore is reported to have been found in this vein. Vein No. 8 is 1 to 2 inches wide, consisting of pink calcite; it was not met with on the level below, the 450-ft. Vein No. 9 is also of pink calcite, about half an inch in width.

In the fall of 1923, vein No. 11 was discovered on the 350-ft. level, a short distance north of vein No. 10. Vein No. 11 strikes about east and west and averages about three inches in width. It was from this vein that the production was obtained.

OXFORD COBALT

The Oxford Cobalt Silver Mines, Limited, has been doing some pioneer work between Giroux and New lakes, about a mile west of the Temiskaming mine; these operations are being carried on by J. W. Russell. The property was examined in August, 1921, and the following information was then obtained.

In the spring of 1921 a small vein of smaltite, about half an inch wide, was discovered on the northeast part of lot No. A. 99. The vein occurs in Keewatin basalt, about 100 feet south of the Nipissing diabase. In this section the diabase dips under the Keewatin. A shaft was sunk on this vein and had reached a depth of 40 feet.

The company was also operating claim C. 1000, which is directly southeast of A. 99. Although the company had, in the summer of 1921, ceased operations on this lot, they had previously sunk a shaft to a depth of 150 feet. The shaft followed a pink, bright-coloured, fine-grained felsite dike, which, at a depth of 37 feet, passed out of the shaft. This dike strikes east 20° north and dips steeply to the northwest. On the 150-ft. level a crosscut was driven 35 feet, where the pink felsite dike was encountered. It was drifted on for 60 feet northeast of the crosscut, and the dike still showed in the face. It was also followed for 20 feet to the southwestward, at which point it was cut off by a prominent joint plane in the rock. A crosscut, 10 feet southeast and 15 feet northwest, failed to locate the extension of the dike.

The dike varies in width from an inch or two to about a foot and may average three or four inches. Here and there, sparingly, the dike contains galena, zinc blende, pyrrhotite, copper pyrites, calcite, epidote, and quartz.

The shaft was sunk in Keewatin basalt. It is difficult to estimate the depth at which the top of the Nipissing diabase sill may be below the surface where the shaft was sunk. But, from the depth at which it occurs at the Beaver, Temiskaming, and Adanac properties, a hint may be obtained as to its possible depth at the Oxford Cobalt.

Since the above information was obtained, Mr. Russell reports that further work has been carried on at the property.

VICTORY

The Victory Silver Mines Company, Limited, has been operating for the past two or three years a 10-acre claim north of the Ophir in southeast Coleman. The writer examined the property in August, 1921, and found that the shaft was down to a depth of 185 feet where a station had been cut and a crosscut driven westward. On August 13th the face of the crosscut was 120 feet west of the shaft. The crosscut encountered a vein of quartz and calcite containing galena, zinc blende, and copper pyrites; this vein is an inch or two in width. Two or three other stringers of calcite, fractions of an inch wide, were also encountered. All these veins strike about north and south and have a vertical dip. No native silver was noted in these veins at the time of examination.

On the 100-ft. level, there was a drift about 25 feet long, following a calcite and quartz vein an inch or two wide. The vein strikes 10° or 15° west of north.

On the 40-ft. level, no drifting had been done, but the shaft had originally been sunk on an incline, following a small calcite vein which, at the 40-ft. level, was less than an inch wide. Later on the shaft was sunk vertically and the inclined upper part made vertical also.

The shaft is about 150 feet south of the north boundary of the claim.

The rock encountered in all the workings is Keewatin basalt. There is a two-inch dike of pink granite in the crosscut on the 185-ft. shaft.

Since the above examination was made, further work has been done, and the writer has been informed that a little high-grade silver ore has been found. The shaft has been sunk to a depth of 450 feet. Through the kindness of the company, the writer was furnished with a report by J. A. MacVichie, the mine manager. The following information is summarized from this report, which is dated November 15th, 1922.

In sinking the shaft a calcite vein was encountered at a depth of about 300 feet, striking north 33° west and dipping 56° northwestward. The vein left the shaft about 21 feet below where it was first met with. It had a width of two to ten inches and contained smaltite and native silver. The report states that: "From the second round we had an assay of silver, 1,676 ounces per ton."

On the 450-ft. level ten veins were said to have been met with, most of them small niccolite and smaltite ones. Vein No. 3 was as wide as 17 inches of calcite and was said to contain some small "spots" of native silver. Vein No. 3 was also said to be wide and to contain some smaltite and "low values" in silver. Veins Nos. 1, 2, 3, and 5 strike northwestward, while Nos. 4, 6, 7, 8, 9, and 10 strike northeastward.

AGAUNICO

The Agaunico mine is situated on the shore of Lake Timiskaming about a mile south of the town of Haileybury. The property has not been productive of silver, but a strong vein of cobalt ore was discovered in the early days of the camp. This vein, which occurs in a fault, has had some stoping done on it.

The writer examined the property in the spring of the year 1920. There is a shaft 400 feet deep. The Cobalt series in this shaft has a thickness of 210 feet. Below this, the rock consists of fine-grained Keewatin basalt to the bottom of the shaft. At the bottom of the shaft, however, there is a soft, schistose dike of mica-lamprophyre. It dips westward and leaves the shaft 25 feet above the floor on the northeast side of the shaft. About four-fifths of the floor is composed of the lamprophyre.

The Keewatin basalt in the shaft contains many pink and white calcite or dolomite stringers, usually less than half an inch wide and a foot or two long. There are also some quartz veins, a few inches wide, in the Keewatin and in the lamprophyre dike. At the bottom of the shaft these quartz veins have a bluish colour.

Some interest was aroused in the Agaunico about the years 1918 and 1919 by the finding on the dump of a dozen or more specimens of a bluish-white quartz containing some native gold. These specimens were all about the size of a man's fist and somewhat resembled the quartz veins in the bottom of the shaft. The rock attached to the specimens was apparently Keewatin basalt; no mica-lamprophyre was noted. In an effort to discover where these rich gold specimens came from, the shaft was systematically sampled in the year 1920 by the owners, and about 100 samples were taken. Most of these samples were blanks, or assayed less than one dollar per ton of gold. It may be added that a careful examination of the quartz stringers in the shaft failed to discover any native gold.

Regarding the cobalt vein, referred to above, the following notes may be put on record. The vein strikes northeastward and dips steeply to the northwest. It occurs in a reverse fault, the displacement of which is probably less than four or five feet. There is a fault breccia, which is in places two feet wide. On the 200-ft. level, the vein is about 60 feet northwest of the shaft. It has been stoped more than 100 feet in length and some 25 feet in height. The vein on the 200-ft. level dips at 80° to the northwest. It varies in width from an inch to six or eight inches; it contains niccolite in places, in addition to cobalt ore.

At the base of the Cobalt series, there is a bed of conglomerate about 10 feet thick, above which is a bed of slate-like greywacké several feet thick. The crosscut on the 200-ft. level from the shaft to the vein follows this bed of greywacké.

On the 55-ft. level the vein has been stoped for a length of over 50 feet and is as wide as eight inches.

PRINCE

The work done on this property consists of a westward crosscut from the 1,400-ft. level of the Beaver mine, and a northwestward drift following a vein on the same level. This vein on the 1,600-ft. level of the Beaver is reported to have produced 40,000 or 50,000 ounces of silver. These workings on the Prince are shown on the plans of the 1,400-ft. level of the Beaver mine.

Some work was also done on the Prince from the 300-ft. level of the Lumsden mine. This work consisted of a crosscut running eastward across the claim to the west boundary of the Temiskaming mine. Near the Temiskaming line a crosscut was run to the south. These two crosscuts are in Nipissing diabase.

The Prince was under option in the year 1923 to the Coniagas.

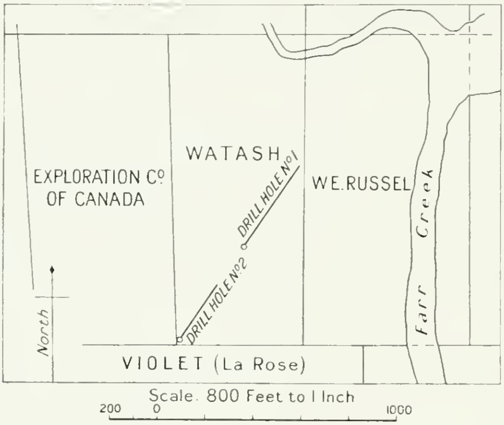


Fig. 42—Plan showing location of diamond-drill holes on Watash.

WATASH

The Watash property lies north of the Violet (Fig. 42). The writer is indebted to T. R. Jones for the following information concerning the diamond-drilling which has been done on the claim.

Two holes were drilled, the location of which is shown on the plan. Hole No. 1 dips at an angle of 45° to the northeast and is 600 feet deep. After cutting through 12 feet of soil, the hole is reported to pass through conglomerate for the rest of its depth, except between 360 and 380 feet which is reported to be diabase.

Hole No. 2 also dips at an angle of 45° to the northeast, and, after passing through 71 feet of soil, is reported to have passed through diabase to a depth of 320 feet, after which conglomerate was encountered to a depth of 421 feet.

The measurements given are along the dip of the holes.

OPHIR AND PEOPLE'S SILVER

The Ophir and the People's Silver mines in the southeast part of the township of Coleman were not accessible. Fig. 43 shows the plans of the levels.

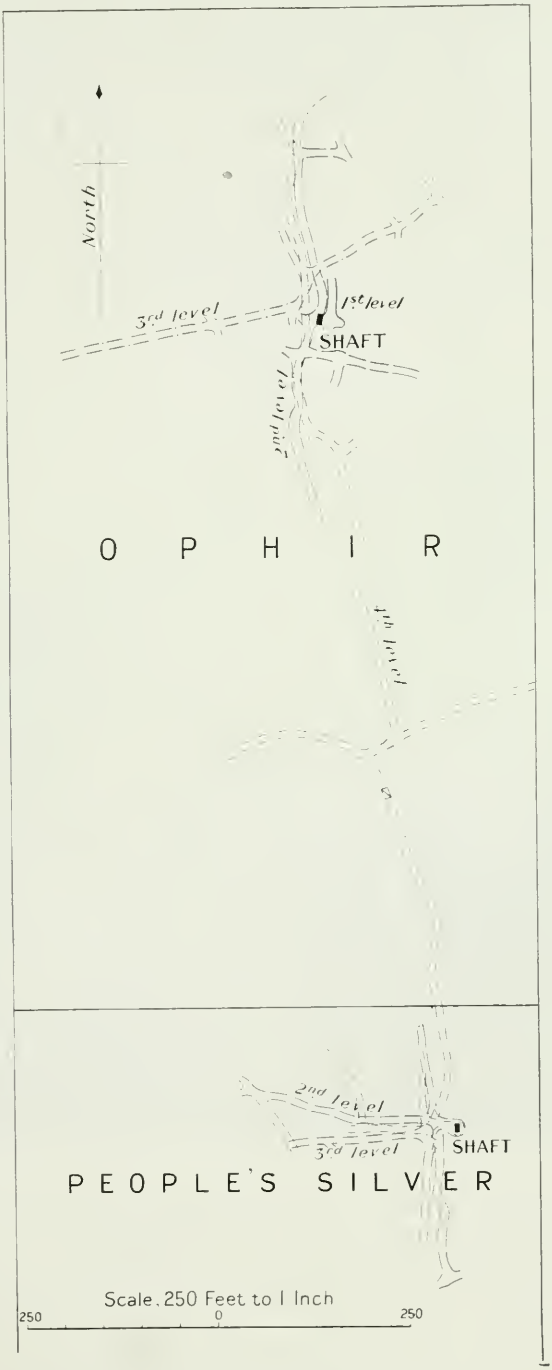


Fig. 43—Plans of mine levels of Ophir and People's Silver.

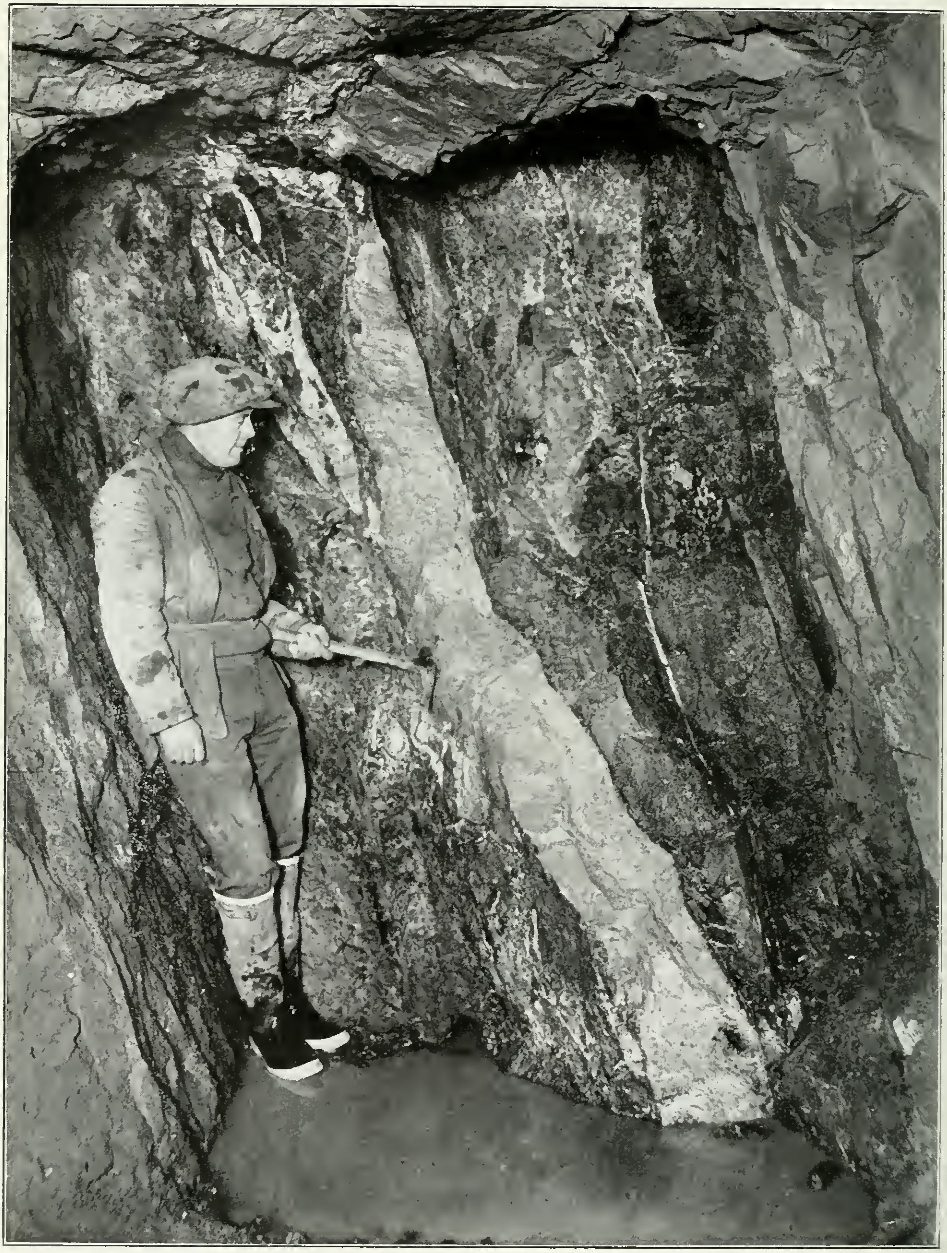


Fig. 44—Wood's vein, north face, Keeley mine, 480-ft. level, October 12th, 1922. The vein averages 10 inches in width and assays 8,000 to 14,800 ounces of silver per ton. This ore is in the Nipissing diabase sill, about 50 or 60 feet below the top of the sill. Leonard G. Smith at the left. Photographed by Cyril W. Knight.

CHAPTER III

SOUTH LORRAIN

INTRODUCTION

The productive part of the South Lorrain silver field occupies a comparatively small area, probably less than one hundred acres. It is sixteen miles southeast of the town of Cobalt. The field may be reached by a road from Cobalt, or by a pleasant twenty-mile trip on a steamboat from the town of Haileybury down Lake Timiskaming. From the wharf at South Lorrain it is about three miles westward over a rough road to the Keeley, Frontier, and Wettlaufer mines.

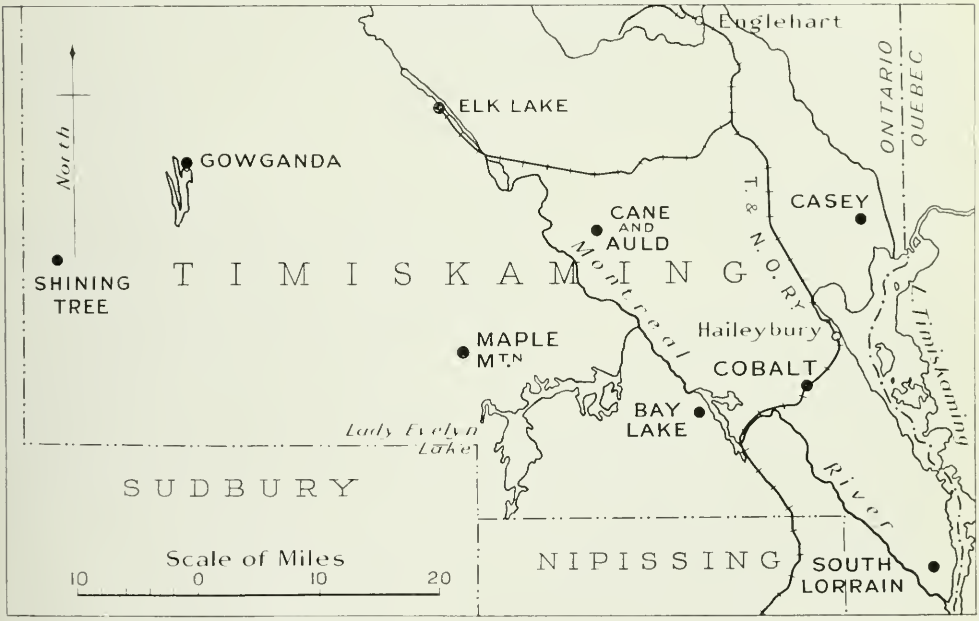


Fig. 45—Plan showing relative position of South Lorrain.

South Lorrain at the present time is attracting much attention owing to rich silver ore-shoots which have been discovered at the Keeley and Frontier mines during the last two years. As a result it is certain that much new exploration will be carried on, with the object of ascertaining whether the present small productive area can be enlarged.

The field was examined in the fall of 1921 and 1922, and brief visits were also made in January and May, 1923. In the year 1922 there were only two operating companies, namely, the Mining Corporation of Canada, Limited, working the Frontier, and the Keeley Silver Mines, Limited, operating the Keeley.

The history of South Lorrain has had its tragic and romantic aspects, its ups and downs. Silver was discovered in 1907 at the Keeley mine, and there followed a period of widespread staking of claims, and of active work lasting until the latter part of the year 1913. During this time, which may be called the first period in the history of the camp, there were produced about 2,446,235 ounces of silver, practically all of which came from the Wettlaufer mine. The Keeley yielded 24,337 ounces, according to the official records of the Ontario Department of Mines.

The camp then became almost inactive for eight years, and was looked upon with little interest by most mining men during that time. To all intents and purposes it was a dead camp.

The credit for the rejuvenation of South Lorrain is due to Dr. J. Mackintosh Bell. He obtained an option on the Keeley mine in 1913, and after efforts lasting for eight years finally succeeded in 1921 in finding rich ore-shoots. South Lorrain thereupon entered the second period of its history, and now gives promise of developing, for the time being at any rate, into the most important of the outlying areas of the entire Cobalt silver camp.

In the rejuvenation of the area Horace F. Strong also played a prominent part. He discovered the first important high-grade ore at the Frontier mine in August, 1921, and through his agency the Mining Corporation of Canada, Limited, acquired this property. J. G. Harkness, who had spent much time in South Lorrain, was associated with Strong in the early development of the Frontier. On following pages are described conditions that militated against the earlier development of the Frontier.

Most people in northeastern Ontario are familiar with the rôle which the Farmers Bank played in the early history of the Keeley mine. The bank was indirectly and vitally interested in the property, and became insolvent partly as a result of the failure of the mine to produce the anticipated quantity of silver for which the promoters of the mining venture hoped. Let this be said for the Farmers Bank: Had the operators known the relation of ore-shoots to the diabase contact, it is probable that the rich ore-shoots along the top of the Nipissing diabase sill would have been found by the early promoters. In view of the high-grade ore which has been discovered recently at the mine along the top of the diabase sill at a depth of 400 to 500 feet, it would appear that the early promoters were justified in their venture. They failed through what would popularly be called hard luck.

The silver veins of the productive area of South Lorrain outcrop on the height-of-land between the Montreal river and Lake Timiskaming, 500 to 600 feet above the lake. The deposits are just over the crest, on the west side of the divide facing the valley of the Montreal river. The country is rugged and generally barren of soil, except in the valley of the river and in isolated spots elsewhere. Along the river valley there are picturesque stretches of agricultural land, fringed by rocky hills, which some day will be turned into as beautiful a bit of farm land as is to be found anywhere in northeastern Ontario. It is desirable that this land be settled now, as a market for farm produce is available at the nearby mines.

A. G. Burrows reported on the South Lorrain area in 1909, his report being based on work carried out in 1908.[1] The surface geology of South Lorrain and also of part of Lorrain township was mapped by A. G. Burrows, James Bartlett, and R. B. Stewart. The accuracy of their work has been acknowledged and appreciated by mine operators and prospectors alike. Burrows found that the formations conformed to the scheme of classification worked out by Willet G. Miller for the Cobalt area proper. When Burrows reported on the area little actual mining had been done, and hence his report did not deal with the geological structures of the rocks and veins at depth. More recently, in 1922, Dr. J. Mackintosh Bell[1] has written a report on South Lorrain, dealing particularly with the Keeley mine.

---

[1] Ont. Bur. Mines, Vol. XVIII, pt. II, 1909.

The writer is greatly indebted to Dr. J. Mackintosh Bell, and to his associates, Messrs. H. Whittingham and Leonard G. Smith, for much information regarding the Keeley and Maidens mines. Dr. Bell gave to the Department extracts from his report on the Maidens mine, and his plan accompanying the report. To Mr. Warren Emens of the Mining Corporation of Canada, Limited, and to the officials connected therewith, the writer is also much indebted for many details concerning the Frontier and Crompton mines. The generous and kindly manner in which the Keeley Silver Mines, Limited, and the Mining Corporation of Canada, Limited, gave to the Department of Mines all the information which was asked for may be put on record here. Mr. Horace F. Strong furnished the Department with plans of the mine levels of the Wettlaufer, and with a stope section of the Wettlaufer vein; he has also very kindly written an account of the history of the Frontier mine, and a description of the Wettlaufer mine. To Mr. Walter J. D. Penly the writer begs to express his thanks for information regarding the location of certain claims.

Production

To the end of the year 1922, South Lorrain had produced 4,339,984 ounces of silver, contributed by the several properties according to the table on page 192.

Vein Minerals

In South Lorrain, the vein minerals are much the same as at Cobalt. The silver occurs largely in the native state and is, as at Cobalt, the most important mineral. Analyses of four samples of cobalt ore were made by Mr. W. K. McNeill, and his results appear in the table below. It will be noted that three of these samples contain only about one per cent. of surphur, which proves that if either cobaltite, the sulph-arsenide of cobalt, or mispickel, the sulph-arsenide of iron, is present, it must occur in small quantity. The first three analyses evidently show, therefore, that the cobalt occurs in the form of the mineral smaltite, the diarsenide of cobalt. The high per cent. of iron in sample No. 2 suggests the presence of löllingite, iron diarsenide, which was identified by H. V. Ellsworth at the Kerr Lake mine.

ANALYSES OF COBALT ORE FROM SOUTH LORRAIN

Constituent	Sample No. 1 per cent.	Sample No. 2 per cent.	Sample No. 3 per cent.	Sample No. 4 per cent.
Cobalt	14.14	9.46	13.38	11.88
Nickel	5.28	0.46	1.50	8.53
Iron	3.37	14.42	4.60	6.20
Arsenic	70.64	63.06	65.40	64.04
Sulphur	1.06	1.48	0.97	4.73
Insoluble	0.20	1.42	0.30	0.70

Sample No. 1 from Frontier mine, Wood's vein, fourth level. Sample No. 2 from Keeley mine stock pile. Sample No. 3 from Curry mine dump at inclined shaft. Sample No. 4 from Keeley mine stock pile.

---

[1] Bulletin of the Institution of Mining and Metallurgy, February, 1922.

SILVER PRODUCTION, TROY OUNCES, IN SOUTH LORRAIN TO END OF DECEMBER, 1922

Total oz. to end 1922	Mine	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922
1,136,917	[1]Keeley	13,124	11,213	......	......	......	......	3,534	....	......	......	39,199	4,586	8,253	281,659	775,349
2,564,584	Wettlaufer	......	183,742	199,920	925,017	834,119	248,992	104,665	....	68,129	......	......	......	......	......	......
42,629	[2]Pittsburgh-Lorrain Syndicate	......	......	......	......	......	......	......	....	7,629	10,000	25,000	......	......	......	......
31,630	Bellellen	......	......	21,213	8,895	......	......	......	....	1,522	......	......	......	......	......	......
556,185	[3]Frontier & Crompton	......	......	......	......	......	......	......	....	......	......	......	......	......	47,227	508,958
7,989	[4]Silver Eagle	......	......	......	......	......	......	......	....	......	......	7,989	......	......	......	......
4,339,934	Total	13,124	194,955	221,133	933,912	834,119	248,992	108,199	nil	77,280	10,000	72,188	4,586	8,253	328,886	1,284,307

---

[1] Keeley produced 1,655,323 ounces in 1923.

[2] Curry and Wettlaufer.

[3] Frontier and Crompton produced 1,300,323 ounces in 1923.

[4] Operated early part of 1918 by John Redington.

Where Veins Occur

The productive veins occur along the top of the Nipissing diabase sill, both in the diabase and in the overlying Keewatin (vertical sections facing pages 193 and 207). In this respect the occurrence is similar to that at the Temiskaming and Beaver mines in Cobalt. The diabase occurs in the form of a great elongated dome, known as the South Lorrain dome, and the productive veins discovered up to the present time have been found on the northwest slope of the dome.

No ore has yet been found in the conglomerate and greywacké of the Cobalt series below the South Lorrain diabase dome. In Cobalt, on the other hand, the rocks below a similar dome, in the Kerr lake-Giroux lake section, have been highly productive, and such mines as the University, Lawson, Crown Reserve, Kerr Lake, and Drummond all occur below the diabase dome in rocks of the Cobalt series.

Pre-Glacial Weathering

In Wood's vein, at the Keeley mine, pre-glacial weathering exists to a depth of at least 480 feet. The weathering has escaped glaciation, and is the only known occurrence of the kind in the entire Cobalt field. The upper part of Wood's vein has been leached and oxidized, and the wall-rock has been changed to red and grey clay for a width of an inch or two to as much as seven or eight feet. This weathering and oxidation is more fully discussed in dealing with the Keeley mine.

The economic significance of pre-glacial weathering in Wood's vein may be important if it is proved that large quantities of secondary silver have been deposited at or near the bottom of the weathered and oxidized zone.

While pre-glacial weathering at the Keeley mine is unique in the Cobalt silver field, it is known, nevertheless, in a few other localities in Ontario. Two notable instances may be cited. At the Helen iron mine, north of Sault Ste. Marie, weathering of a diabase dike and Keewatin schist has taken place to a depth of 540 feet, according to A. L. Parsons. These rocks are altered to grey kaolin.[1] In Hastings county, at the Eldorado copper mine, weathering of iron and copper sulphides has taken place to a depth of 60 to 80 feet, the sulphide having been changed to iron oxide, which yielded a good grade of iron ore. Below the weathered zone primary sulphides were met with. E. L. Fraleck has described this occurrence.[2] In certain other hematite deposits in southeastern Ontario similar conditions occur, the iron ore passing into sulphide in depth.

Length of Ore-Shoots

The ore-shoots at the Keeley and Frontier mines are shorter than are those at Cobalt. The most consistent high-grade shoot in the Keeley is 74 feet long in vein No. 26; "N" shoot in Wood's vein on the seventh level is 198 feet long. On the 300-ft. level of the Crompton there is a shoot of high-grade 102 feet long in Wood's vein. If we compare the South Lorrain shoots with certain shoots at Cobalt, we shall obtain a just idea of their relative lengths. The stope on the Meyer shoot, with its westward extension on the Trethewey, is about 1,600 feet long. The stope on the O'Brien No. 1 vein on the second level is 900 feet long at the west end of the property. The stope on the No. 3 vein of Kerr Lake is 400 feet long. Other examples might be given.

It may be, of course, that longer shoots will be found in South Lorrain as development and exploration proceed. The writer has not seen the stopes in the Wettlaufer mine. He was, however, given the stope section of the Wettlaufer vein through the kindness of Horace F. Strong; the section shows one of the stopes to have a length of 210 feet on the second level, and 260 feet on the third level.

---

[1] Annual Report, Ont. Bur. Mines, Vol. XXIV, pt. I, 1915, pp. 192-194.
[2] Ont. Bur. Mines, Vol. XVI, pt. I, 1907, p. 182.

While the South Lorrain ore-shoots have not yet proved to be as long as those at Cobalt, some of them are very rich. At the Keeley mine, J. Mackintosh Bell reported that in drifting 74 feet along vein No. 26 on the 480-ft. level not less than 250,000 ounces of silver had been mined; no stoping was done in recovering this huge amount. On the 300-ft. level of the Crompton a shoot on Wood's vein 102 feet long and an average height of 35 feet had produced 900,000 ounces of silver to the end of April, 1923.

The "Mother Lode"

The vein-system in the productive part of South Lorrain is an interesting one. The main vein is known as the Wood's vein. It has been named by Dr. J. Mackintosh Bell the "mother lode" of the productive section. It is in a reverse fault, the displacement of which is about 30 feet, and most of the productive veins are probably branches. The relation of the Wettlaufer vein to Wood's vein is not known. The Wettlaufer vein strikes towards Wood's vein at an angle of about 45°, but, in so far as the writer can ascertain, it has not yet been followed to its intersection with the Wood's. According to Horace F. Strong, it "feathers" out about 50 feet southwest of the northeast corner of the Curry, H.R. 105.

Faults[1]

The faulting system in South Lorrain is believed to be a complex one. The two main faults are the Lake Timiskaming fault on the east, following the course of the lake. and the Montreal river fault on the west, following the general course of the river. The former strikes north and south, the latter southeastward, so that the two faults join about five miles south of the Keeley mine about at the point where the Montreal river enters Lake Timiskaming.

Between these two major faults it is believed that there are many minor faults, although the only one which has been positively proven to exist is Wood's fault with its small branch faults. The evidence for stating that many other faults exist is the presence of sharply defined valleys. It if is assumed, for the moment, that these valleys are fault valleys, then the number of faults between Lake Timiskaming and the Montreal river is great.

At the north end there is Maidens creek valley striking westward, a few degrees north of west. Running about at right angles to the Maidens creek valley are a number of valleys entering it from the south; one of these begins at the northeast corner of Trout lake, and, striking about north-northeast, passes through the Wettlaufer claim, and then continues to the Maidens valley, a total distance of two and a half miles. This fault may be called the Wettlaufer valley fault. East of this there is probably another fault along the east arm of Loon lake, which continues north-northeast to Maidens valley. The Loon lake fault appears to be exposed to view a few hundred yards south of the lake, where the conglomerate is crushed into a rock similar to the fault breccia found in faults. This breccia is cemented by calcite, dolomite, or other carbonate.

Wood's fault has been proven to strike southward through the Frontier, Crompton, Keeley, and claim No. H.R. 103. It may join the Wettlaufer valley fault at some point near the northeast corner of Trout lake. Another fault, entering from the eastward from a little lake on H.R. 98, also seems to join Wood's fault at or near the point that the Wettlaufer valley fault joins it. Another valley enters Trout lake at the northwest corner. Thus there appear to be several faults entering the north end of Trout lake. If these faults, or veins connected with them, contain commercial quantities of silver, they present an interesting problem.

---

[1] The Cobalt-Nickel Arsenides and Silver Deposits of Timiskaming, by Willet G. Miller, Annual Report, Ont. Bur. Mines, Vol. XIX, 1913, pt. II, pp. 116-121.

Some of the valleys referred to above are indicated on the map of South Lorrain by A. G. Burrows.

There are several other prominent valleys not mentioned above, notably that about half a mile west of the Frontier mine; and there are also a number of sharp cliffs suggestive of faulting.

A word may be added as to the character of the faults. The Lake Timiskaming fault was first pointed out by Willet G. Miller.[1] Later, G. S. Hume[2] showed that the fault has a displacement of 800 to 1,000 feet, the east side being the down throw side. The character of the Montreal river fault, whether reverse or normal, is not known; nor is the character of any of the other faults known, except Wood's fault at the Frontier and Keeley, which appears to be a reverse fault with a displacement of about 30 feet.

A word of caution must be added about assuming that all the valleys in South Lorrain represent faults. A valley in Cobalt may be cited which proved to have no fault. This is the valley along which runs the branch line of the Temiskaming and Northern Ontario railway from Cobalt to Kerr lake, opposite the cliff at the "Little Silver" vein on the Nipissing property. The underground workings penetrated below this valley, and no evidence of a fault was found. This may be the case in more than one valley in South Lorrain.

Discovery of Ore Bodies

To those, and there are many, who want to know the likely places in which to explore in South Lorrain, the writer can do no better than to point out how success was achieved during the last two years at the Keeley and Frontier properties. The operators began working at the surface on strong calcite veins, an inch to a foot or more in diameter; these veins contained small shoots of cobalt ore; the silver was negligible. The veins outcropped in Keewatin rocks three to four hundred feet above the top of the Nipissing diabase sill. The operators sank on the veins to the contact of the Nipissing diabase and Keewatin basalt. Exploration of the veins along and near the contact revealed the rich ore-shoots which have brought the camp into such prominence. Another factor, however, besides the diabase contact played its part at the Keeley mine. J. Mackintosh Bell believed that, at or near the bottom of the pre-glacial weathered zone in Wood's vein, he would find rich masses of secondary silver ore which had been leached out of the top part of the vein. While the bottom of the weathered zone has not yet been reached at a depth of 480 feet, there is evidence nevertheless that the workings are approaching it. At any rate, most of the high-grade ore in the mine has been encountered at this depth.

Those seeking new ore bodies in South Lorrain should also keep in mind the conglomerate and greywacké of the Cobalt series below the South Lorrain dome, in the vicinity of Loon and Oxbow lakes. Up to the present time no calcite veins of importance are known in these rocks under the dome. Should strong calcite veins, with smaltite, be discovered by trenching or diamond drilling such veins might be explored along the base of the Cobalt series. In Cobalt much of the silver ore occurs along the base of that series; similar conditions may exist in South Lorrain under the diabase dome.

---

[1] Annual Report, Ont. Bur. Mines, Vol. XIX, pt. II, 1913.

[2] The Ordovician Rocks of Lake Timiskaming, Geol. Surv. Can., Museum Bulletin No. 17; Am. Jour. Sci., 4th ser., Vol. 50, 1920, pp. 293-309.

Maps and Plans

In the pocket at the back of the report will be found a detailed surface geological map of the productive area of South Lorrain, on a scale of 400 feet to an inch. The map shows the kinds of rocks, the location of the veins, contour lines, buildings, and so on. This map was prepared by the Mining Corporation of Canada, Limited, in co-operation with the Keeley Silver Mines, Limited. The work is wholly theirs, and the geology is based on A. G. Burrows' map, scale one mile to an inch, published in 1909 by the Ontario Department of Mines. The writer herewith expresses the thanks of the Ontario Department of Mines for the generous manner in which the companies concerned handed over the entire map for publication in this report. The map was made by the companies on a scale of 100 feet to an inch; the Department has published it on a scale of 400 feet to an inch.

In the pocket will also be found a sheet showing the plans of all the levels of the Keeley and Frontier mines. The geology, veins, faults, and so forth, are shown.

General Geology

The following classification of the rocks in South Lorrain is largely based on that given in the report of A. G. Burrows,[1] to which the reader is referred. The rocks have been fully described in Burrows' report, and it is not necessary to add much, beyond referring to the presence of lamprophyre dikes of Haileyburian age which have since been found. The Nipissing diabase has, since the early work, been proved to occur in the form of a sill with a great dome-like structure. In view of the importance of this dome structure, the writer has described it in somewhat great detail in following pages.

Table Showing Rock Classification of South Lorrain

PRE-CAMBRIAN	Keweenawan	Silver veins. Nipissing diabase sill.
		Intrusive Contact
	Animikean (Cobalt Series)	Lorrain quartzite, arkose and conglomerate. Conglomerate, greywacké, slate-like greywacké, quartzite.
		Great Unconformity
	Algoman	Granite and syenite, feldspar-porphyry.
		Intrusive Contact
	Haileyburian	Lamprophyre dikes.
	Keewatin	Basalt and similar basic lavas, much altered in places.

The South Lorrain Diabase Dome

The Nipissing diabase in South Lorrain occurs, as in Cobalt, in the form of an irregular sill, hundreds of feet thick. Its exact thickness in South Lorrain is not known, and will not be until the diamond drill or shafts have penetrated it.

The sill has the shape of a great elongated dome, the longer axis of which strikes northeastward. The dome structure is illustrated in the drawing facing page 193, which shows a vertical section at right angles to the longer axis. A study of this vertical section, and the plan accompanying it, will explain the structure much better than a page or two of text.

---

[1] Annual Report, Ont. Bur. Mines, Vol. XIX, pt. II, 1913, pp. 134-144.

It is believed that the dome-like structure of the diabase sill was not caused by folding, but that the diabase was intruded in that form during its molten state. Of course there may have been a little subsequent folding, but the gentle dips of the slate-like greywacké and conglomerate of the Cobalt series show that there has been comparatively little disturbance.

The top of this diabase dome, during a great period of time, has been slowly eroded and worn down until, finally, all that now remains of the dome is the lower part with its encircling arms dipping away from the centre.

Contacts of the bottom of the diabase sill with the underlying rocks around the inside of the dome are exposed in a score of places, showing the diabase dipping away from the centre at angles varying from 5° or 10° to as high as 65°. Similarly, the top of the diabase sill around the outside of the dome is exposed in many places, and the top of the sill may be seen plunging under the older rocks at angles of 15° to as high as 80° or 90°. The almost vertical dips along the top of the sill were noted in the valley of Maidens creek along the north part of the dome.

Details of the South Lorrain Diabase Dome

As the dome-like structure of the Nipissing diabase sill is one of the most important structures in South Lorrain, it is described rather fully.

The evidence proving that the diabase forms a dome may readily be obtained by following the contacts around the inside and outside of the dome. The contacts around the inside of the dome show the bottom of the diabase sill; while the contacts around the outside of the dome show the top of the diabase sill. The contacts which were found may now be described in detail, beginning with the outside of the dome on the shores of Lake Timiskaming, at Maidens creek, half a mile north of the government wharf.

The Outside of the Diabase Dome (Top of the Sill)

The actual contact of the top of the dome is heavily covered with drift for a mile and a half westward from the shore of Lake Timiskaming. The contact appears to follow the south side of Maidens creek valley. The first contact observed was found on or near claims Nos. R.L. 461 and H.S. 11, where it is excellently exposed, particularly at one place. At this place a hill rises about 25 feet high, and the contact goes up one side and down the other, and is seen to be vertical. The actual contact is exposed for about 60 feet. Elsewhere on the two claims mentioned above, there are half a dozen contacts exposed, but the dip of the diabase is obscure and could not be positively determined; at one place, indeed, the diabase seemed to be resting on top of the Keewatin. This may, however, be a local irregularity.

Half a mile northwest the contact is again excellently exposed in a valley, through which the main road runs, on claim No. B.C. 105. The valley cuts across the contact at right angles. Standing at the bottom of the valley and looking southeast up the hill, the contact of the diabase is seen to extend up the hill. It is vertical. Similarly, standing in the valley and looking northwest, the contact is seen to extend up the other side of the valley and to be also vertical. The rock with which the diabase is in contact is a pink quartzite. The colour of the quartzite makes a sharp contrast with the dark colour of the diabase. The contact is vertical for at least 50 to 75 feet.

The vertical contacts described in the preceding paragraphs are along the north side of the diabase dome, where the only known vertical contacts have been found. There is no way of determining to what depth this vertical contact extends except by diamond-drilling or shaft-sinking. A knowledge of the dip of the diabase at the Maidens claim, H.R. 69, is of practical importance on account of the veins which occur there.

The northwest end of the diabase dome terminates in a spur about 300 yards wide. At the north end of this spur, a shaft has been sunk in the diabase near the quartzite. The shaft dips about 55° or 60° to the southwest. The rock on the dump is diabase. There are on the dump pieces of a pink calcite vein about three or four inches wide carrying a little cobalt bloom. The latter mineral may be seen in place in a joint in the rock about six feet southeast of the shaft. Evidently the inclined shaft was sunk on this joint. West of here about 450 feet another shaft has been sunk, apparently at the contact between the diabase and quartzite. This shaft is in a valley, the contact here following the valley as it curves around to the west, southwest, and south. The rock on the dump from this shaft is coarse and fine grained diabase.

From the north end of the spur the contact runs about due south for nearly four miles to the south end of Trout lake. This part of the contact, up to the present time, is the most important part in the whole South Lorrain area because the productive properties, Wettlaufer, Keeley, and Frontier, occur here.

Fig. 46—Mr. J. M. Wood

Fig. 46a—Mr. R. J. Jowsey

These partners were pioneers in South Lorrain and joint discoverers of the Keeley mine. The "Wood's" vein was named after Mr. Wood. The Keeley mine was named after Mr. Charles Keeley who was associated with Jowsey and Wood.

Commencing at the north end of this important part of the sill the contacts may be described in detail.

About 300 yards south of the north end, fine-grained diabase occurs along the side of a hill. The slope of the hill appears to indicate the dip of the diabase, namely, about 30° or 35° to the westward. The diabase here is dipping under conglomerate and greywacké of the Cobalt series.

The first satisfactory place to examine the contact along this four-mile stretch is about three-quarters of a mile south of the north end of the dome, on claim No. R.L. 467, known as the Alice Lorrain. A shaft has been sunk on this claim. About 125 yards southwest of the shaft, the contact is excellently exposed for about 40 feet; the contact dips steeply westward under the Keewatin.

South of here three claims, on the Lorrain Consolidated property, No. H.R. 24, the contact is excellently exposed along the side of a hill. It dips to the westward at 15° to 22°, but is much steeper in places. South of this exposure the contact goes below swampy or low ground, and is not exposed until the Keeley property is reached, where at the roadside, about 75 yards from the old Keeley shaft, it dips westward. Between this last-mentioned exposure and the Wettlaufer mine, there are several excellent exposures of the contact, all dipping westward under the Keewatin.

At the Frontier, the diabase dips about 25° to the westward in the vicinity of No. 1 shaft; this dip is shown by the mine workings.

At the Keeley, to the south of the Frontier, the dip of the diabase is about 34° westward; this dip is also shown by the Keeley workings. The drawings facing pages 207 and 219 show the dip of the diabase contact at the Keeley and Frontier.

The Wettlaufer mine was flooded at the time of examination of the area in October, 1922, so that it could not be inspected. But it was learned from those who had examined this mine that the diabase dips below the Keewatin at steep angles. On the surface the contact is exposed at more than one place, and is particularly well shown near the east side of the valley, where the diabase dips under the Keewatin at an angle of about 15°. From this exposure southward to Trout lake the contact is covered with soil.

At the south end of Trout lake, on the east side, the contact between the conglomerate of the Cobalt series and the top of the Nipissing diabase is well exposed. At two places the contact dips 45° to the westward. Southeastward from here about two claims, on No. H.S. 497, the diabase contact is exposed on the side of a bare hill and dips 44° to the south. This contact is located at about the most southward part of the Nipissing diabase dome.

Northeast of here, on the next claim, No. H.S. 500, the contact is well exposed in three places, dipping from 36° to 51° to the southeast. Two of these contacts are on the side of a hill. It may be noted here that many of the contacts observed in South Lorrain are on the side of valleys, as frequently as they are in the bottom of valleys. On H.S. 500 little acid dikes from one-half to two inches wide intersect the diabase; these dikes were noted elsewhere in the area.

Northeast of the last-mentioned contacts about a mile, the contact is exposed on H.R. 113, but the dip could not be ascertained.

Two claims to the northeast, on H.R. 54, at the northwest corner, the contact is exposed in two places dipping 41° and 55°, respectively, to the southeast. The Keewatin basalt is here altered to a banded, slightly schistose rock; the diabase has cut about at right angles across the banding, making the contact sharp and clear-cut.

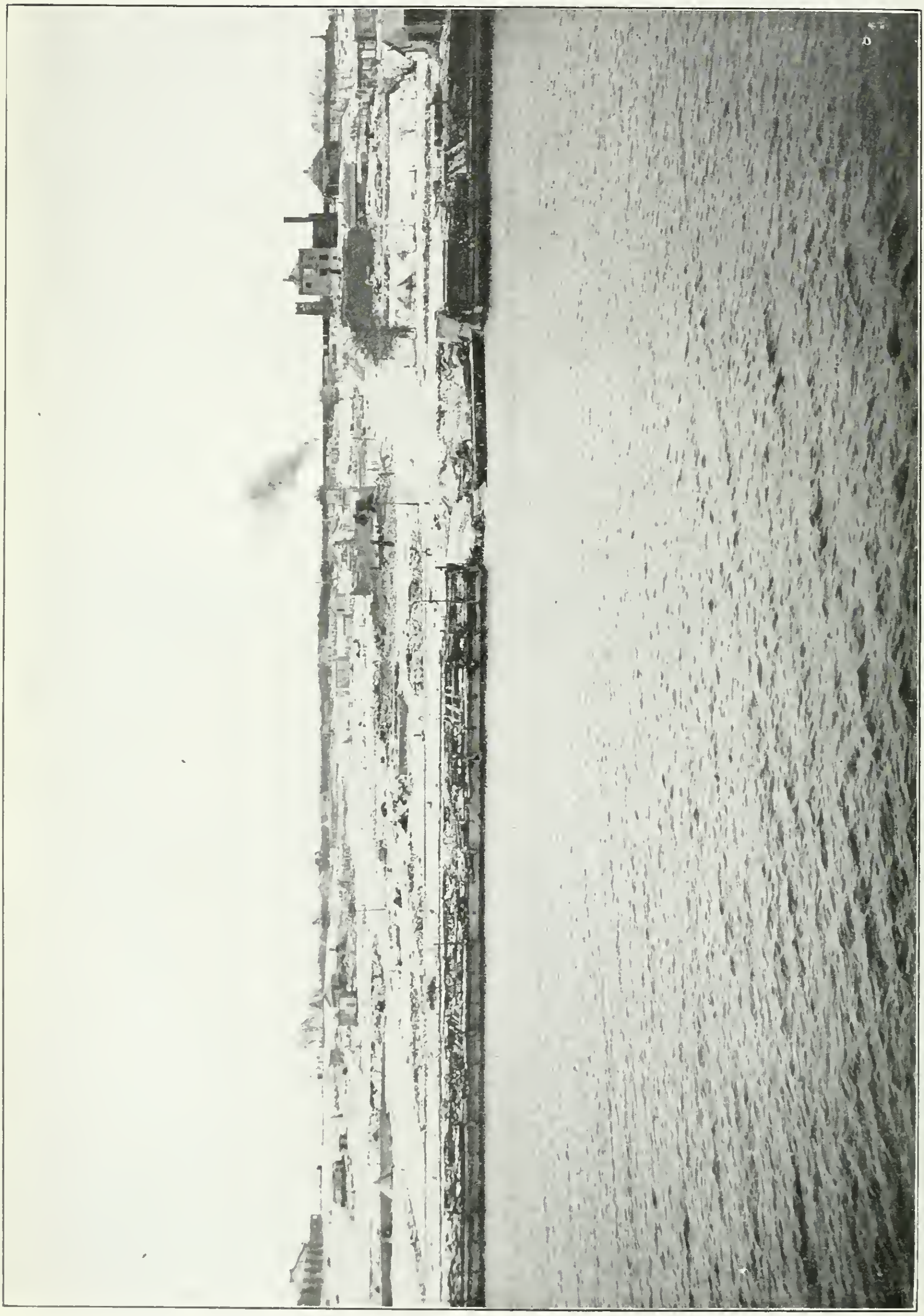


Fig. 47—Haileybury, five miles north of Cobalt, Oct. 27th, 1922, after the great fire of Oct. 4th, 1922. Lake Timiskaming in the foreground.

Northeast of the last exposure the contact is again exposed on H.R. 27 at the northeast corner. Judging by the jointing in the diabase, the contact dips 25° to the southeast.

From this point eastward to the shore of Lake Timiskaming, the contact is drift-covered, except at the hill on the side of the lake. Here, near the north end of claim No. H.S. 308, the contact is exposed in two places about 40 feet apart, one exposure being just north of the boundary and the other just south of it.

The contact dips 25° to 30° to the southeastward. The Keewatin basalt is altered to a banded rock with streaks of epidote paralleling the banding; the diabase cuts about at right angles across the banded basalt, and the contact is sharply defined in consequence. At the foot of the hill the coarse-grained Nipissing diabase is exposed, and a shaft has been sunk in it.

In the preceding paragraphs we have followed almost completely around the outside of the Nipissing diabase dome. The east part of the dome is partly covered by the water of Lake Timiskaming, but outcrops on the Quebec side of the lake along the shore. According to the geological map-sheet No. 1066, of the Geological Survey of Canada, the diabase contact near the shore is drift-covered.

The contact along the inside of the diabase dome may now be followed, commencing at the shore of Lake Timiskaming at the south end of claim No. H.R. 61.

The Inside of the Diabase Dome (Bottom of the Sill)

The bottom of the Nipissing diabase is well exposed a little over half a mile west of Lake Timiskaming on or near claim No. H.R. 30. Forest fires have destroyed the trees, and lines are difficult to find. At the foot of a low cliff the diabase contact is exposed in two places, resting on finely bedded slate-like greywacké of the Cobalt series. The contact follows the bedding; contact and bedding dip 9° to the northwest at one point and, at another 200 feet north, 13° to the northwestward. The jointing in the diabase is well defined along the contact, the most prominent jointing being at right angles to the contact.

From claim H.R. 30 westward to the northwest shore on Loon lake, a distance of a mile, the contact is either heavily drift-covered or hidden under the water of Loon lake.

Southward from the northwest corner of Loon lake for half a mile, the contact of the bottom of the diabase sill is exposed in half a dozen places. Prospectors have trenched it here and there. The contact has a semicircular outline along this part, so that the dips strike from southwest, to west, to northwest, at angles of 10° to 35°. This semicircular outline of the contact is due to a local arching of the bottom of the sill, the arch striking apparently about northwestward along the west arm of Loon lake. At the top of the arch the diabase is resting on pink arkose and quartzite, while at the bottom of the arch, on the southwest side, the diabase rests on finely bedded slate-like greywacké. Where it lies on the slate-like greywacké it follows the bedding for a distance, then it leaves the bedding and rips upwards across the bedding, resting on the sediments at a higher and higher horizon, until it finally rests on the pink arkose and greywacké at the top. The succession of the sediments of the Cobalt series in this place is as follows, the older rocks being shown at the bottom of the column:

Arkose and quartzite.
Greywacké and slate-like greywacké.
Coarse boulder conglomerate.

The bedding of the slate-like greywacké dips at 10° to 14° to the northwest. The greywacké and slate-like greywacké have a thickness of 50 to 60 feet, and the total thickness of the whole section is from 150 to 200 feet. The coarse boulder conglomerate is at the bottom of the section; its thickness is not known. The arkose and quartzite are similar to the Lorrain arkose and quartzite, while the greywacké, slate-like greywacké, and conglomerate are typical of the Cobalt series. The sediments are all conformable.

In places faulting has occurred parallel to the contact in the area southwest of Loon lake described in the two preceding paragraphs. The faulting is indicated by the presence of a fault breccia 15 inches or less in width; the direction and displacement of the faulting were not determined.

Southwest of the area described in preceding paragraphs the diabase contact is covered for three-quarters of a mile, when it is again well exposed on the south shore of a small lake on claim H.R. 98. The contact is exposed for 50 feet dipping at 40° and more to the westward.

About 250 yards south of the little lake the diabase contact is again exposed for about 40 feet; judging from the joint planes in the diabase, the bottom of the diabase sill here dips southwestward 30° to 40°. The slate-like greywacké nearby dips at 10° to the southwest.

South of the exposure referred to in the preceding paragraph another contact is exposed, but the direction of the dip is obscure. The slate-like greywacké dips 10° under the diabase.

About 200 yards north of the west arm of Oxbow lake, another contact is exposed for 50 feet. The dip is obscured by a fusion between the diabase and the sediments; the jointing in the diabase dips 38° westward.

Oxbow lake constitutes the south end of the inside of the Nipissing diabase dome, and the contact of the bottom of the sill follows the bed of the lake in a rough semicircle, the contact being covered by water for more than a mile.

The southeast side of the dome dips at steeper angles than the northwest side, and the diabase sill along the southeast side appears to be thinner than elsewhere.

For a mile northeast of the east arm of Oxbow lake, the bottom of the diabase sill is drift-covered. Then, 200 feet southwest from the northeast corner of claim H.R. 34, the contact has been exposed in a trench. Here the diabase is resting on altered Keewatin basalt which has a banded structure. The contact dips at 62° to the southeast.

From the last-mentioned exposure northeast for a mile and a half to Lake Timiskaming, the contact is drift-covered, and it then passes below the waters of the lake.

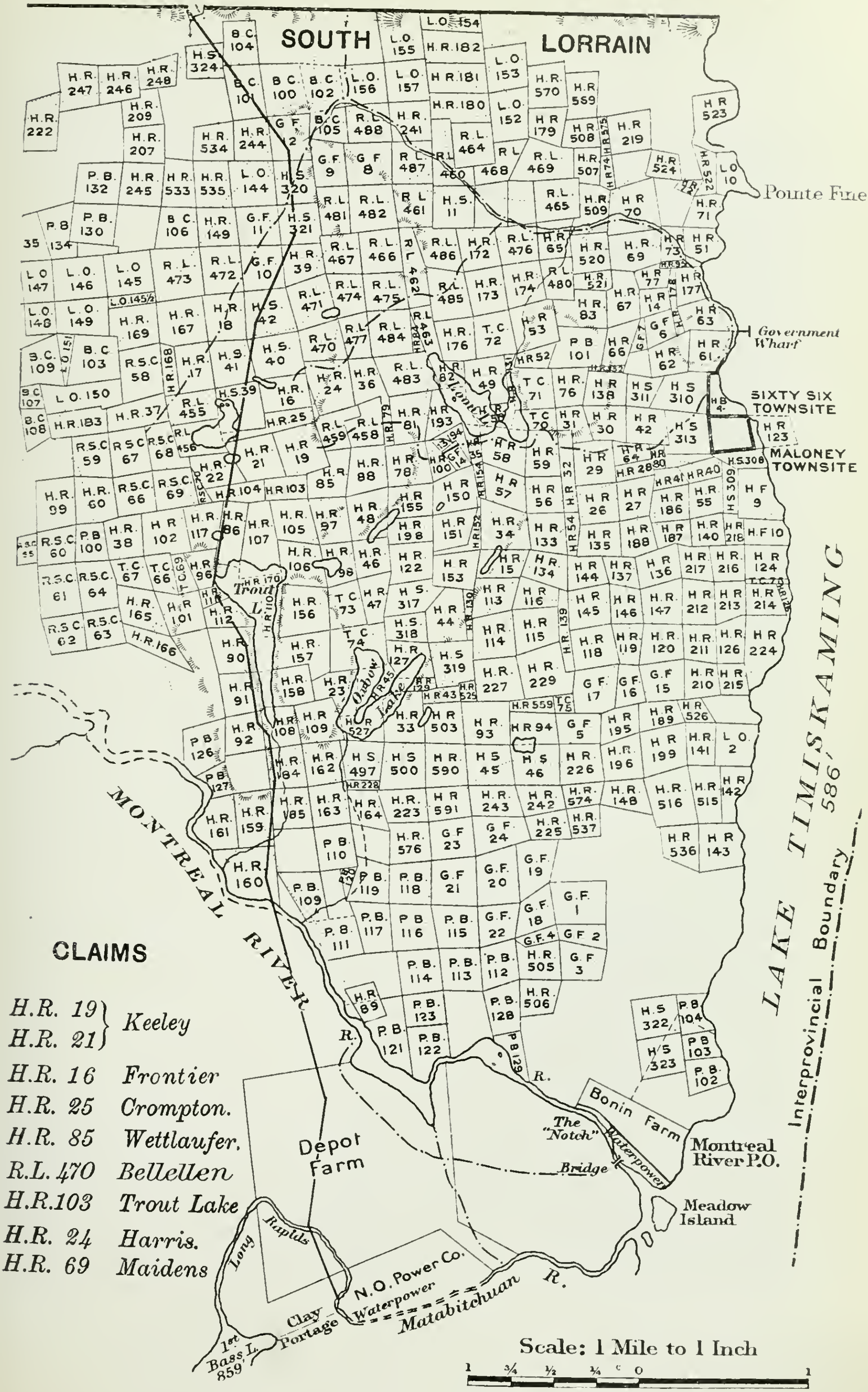
DESCRIPTION OF PROPERTIES

Keeley

The Keeley Silver Mines, Limited, has a capital of 2,000,000 shares having a par value of one dollar a share. All the shares have been issued. The company bought the original Keeley claim, H.R. 19, and the claim immediately to the west, H.R. 21, known as the Beaver Lake claim.

The property was examined in the fall of 1921 and 1922, and brief visits were also paid during the latter part of January and early in May, 1923.

The first discovery was made by J. M. Wood and R. J. Jowsey on the original Keeley claim, H.R. 19, in the fall of 1907, and the first shipment of ore from the discovery was made by the owners of the claim, Charles Keeley, R. J. Jowsey,



CLAIMS

H.R. 19 H.R. 21	Keeley
H.R. 16	Frontier
H.R. 25	Crompton.
H.R. 85	Wettlaufer.
R.L. 470	Bellellen
H.R. 103	Trout Lake
H.R. 24	Harris.
H.R. 69	Maidens

Fig. 48—Plan showing claims in South Lorrain.

and J. M. Wood, in the spring of 1908, and was received by the Deloro Mining and Reduction Company, Limited, Deloro, Ont., on the twenty-second of June of that year. The shipment consisted of twelve tons, dry weight, assaying 1,061 ounces of silver per ton. The value of the shipment was $6,068.52, of which amount $170.32 was credited to the cobalt and arsenic content. In the latter part of March, 1908, Mr. James Bartlett and the writer examined the open pit from which this shipment was made.[1] The pit was about 40 feet long and 14 feet deep, and the vein had a width of two to six inches showing some pure smaltite and wire silver.

The following account of the discovery of the Keeley mine has been kindly furnished by R. J. Jowsey:—

> The find on the Keeley was made in the fall of 1907. J. M. Wood had been digging while I had gone to Haileybury for some provisions. I went to Haileybury on the last trip of the boat, and the lake froze, so I had to pack the supplies down on my back. When I returned Wood had found a chunk of smaltite, and had it in the camp when I arrived. I went out and helped him dig that evening, and next day, about three o'clock, he uncovered the vein when I was a little farther ahead in the trench. We left it on the window sill a couple of days, as it looked to be just smaltite. On Sunday we were looking at it when it had dried out, and noticed all those fine hairs in it. We were not sure of its value, so we had it assayed. If I remember right it was around 11,000 ounces of silver per ton.

Messrs Keeley, Jowsey, and Wood then sold the property to interests connected with the now defunct Farmers Bank. The bank was only interested in the property on account of having made advances on a million dollars worth of bonds issued by Keeley Mine, Limited; and the bank was never owner of the mine. Keeley, Jowsey, and Wood received $300,000 for the property. The total amount advanced by the bank, including the purchase price, wages, cost of plant, etc., was much greater than the above mentioned sum.

The property, under the name of Keeley Mine, Limited, was worked by interests associated with the bank until 1911, and about 24,337 ounces of silver were produced, mainly from the original discovery, No. 1 shaft. Wood's vein was not worked during this period in the history of the mine.

The affairs of the Farmers Bank then became involved, and the bank failed. The liquidators of the bank found themselves in possession of the Keeley mine, H.R. 19, but they did not allow the operating company, Keeley Mine, Limited, to fail. It was kept in good standing.

In 1913, J. Mackintosh Bell acquired an option on the property for the Associated Gold Mines of Western Australia, Limited. An option had been granted on the 26th March, 1913, by Keeley Mine, Limited, and the Farmers Bank to one, E. G. Aman, which option was assigned to the Associated Gold Mines of Western Australia, Limited, on the 12th June, 1913. The Associated Gold Mines of Western Australia, Limited, obtained several renewals of that option, and on the 23rd April, 1918, they obtained the last option. These were given by the Keeley Mine, Limited, and the Farmers Bank. The final payment on the property was made on August 1st, 1919; the total price paid was $110,000. Upon the Associated Gold Mines of Western Australia, Limited, making the final payment they received a transfer from Keeley Mine, Limited, and the Farmers Bank of the property, and they also received the majority of the stock in Keeley Mine, Limited, and the bond issue of a million dollars made by Keeley Mine, Limited, which was held by the Farmers Bank. Eventually these bonds were burned by J. Mackintosh Bell and the solicitor of the present company, W. H. Stafford. The writer is greatly indebted to these two gentlemen for much of the information regarding the history of the property.

---

[1] Annual Report, Ont. Bur. Mines, 1907, Vol. XVI, pt. II, p. 147.

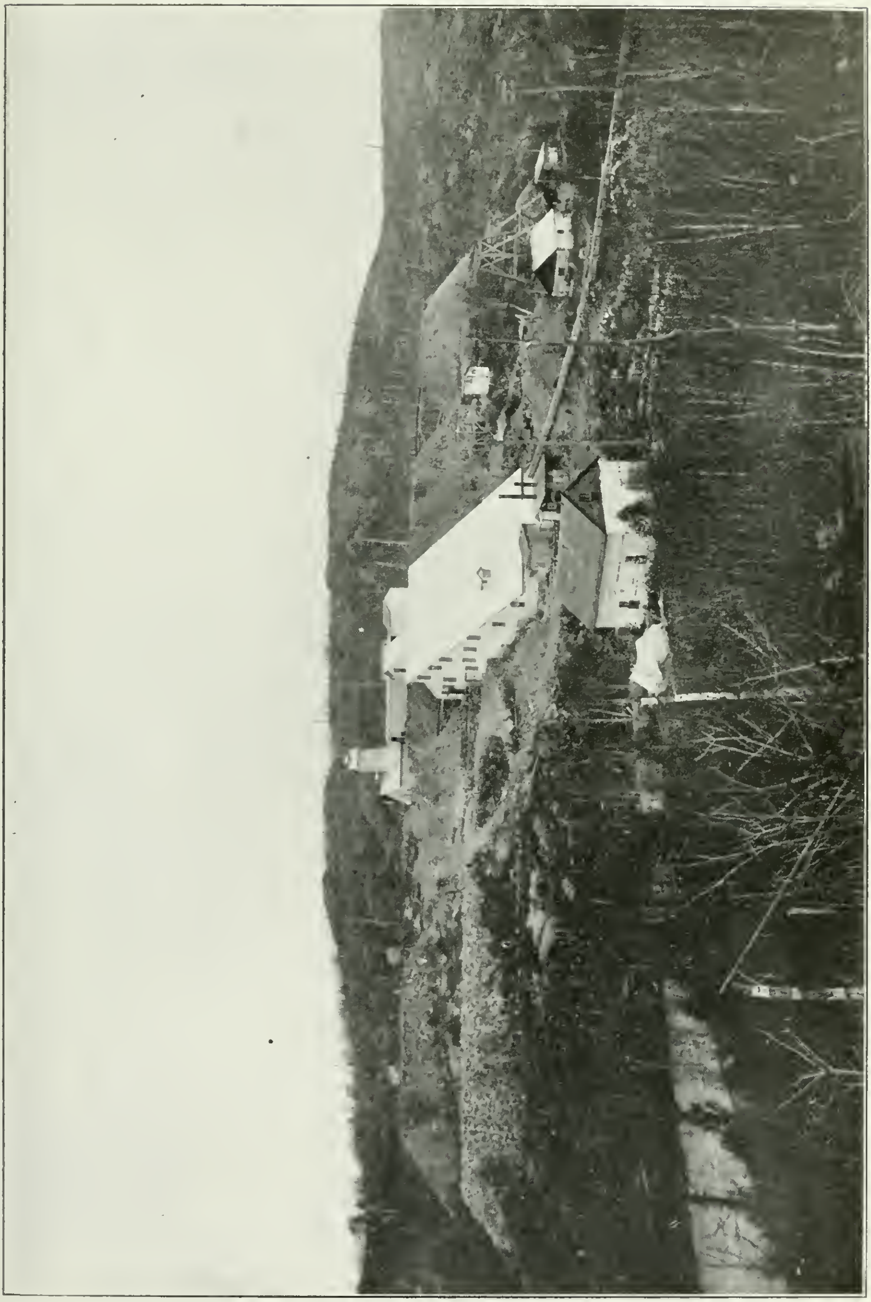


Fig. 49—Keeley mine and mill, October, 1922.

The Associated Gold Mines of Western Australia, Limited, did not operate the original discovery at the Keeley mine, No. 1 shaft, nor have these old workings been connected with the main, present-day workings on Wood's and other veins at No. 3 shaft.

Between the years 1913 and 1919, work at the property was retarded and carried on intermittently on account of the Great War which lasted from 1914 to 1918. In 1914, the mine was worked with a force of 85 men, but, following the outbreak of war, the force was reduced in August from 85 to 20 men, and in September to 6 men, who were sinking by hand in No. 2 shaft. The mine ceased operations about the middle of October, 1914.

In 1915, the mine was worked from May to October 1st. In 1918, a shipment of ore, in stock from previous operations, was made; and the property was in operation between July and September. In 1919, work was carried on during the summer months with a force of 15 men.

Subsequent operations have been highly successful, and the mine has been operated without cessation up to the time this report went to press.

On account of the fact that Wood's vein, the "mother lode" of the productive section, was first discovered on the Beaver Lake claim, a few words may be added about its history. The claim, as already noted, is now owned by the Keeley Silver Mines, Limited, and is contiguous to the original Keeley, H.R. 19, on the west.

Wood's vein was discovered in 1908 by J. M. Wood on the Beaver Lake claim, H.R. 21. The southern two-thirds of the vein outcrops on the Beaver Lake claim; the northern third of the vein passes into the original Keeley claim In 1908 and 1909, Jowsey and Wood sank a shaft on Wood's vein, on the Beaver Lake claim, near the west boundary of the Keeley. The shaft was sunk to a depth of 110 feet, and on the 75-ft. level a drift 75 feet long was run. Had Jowsey and Wood drifted a short distance farther north they would have encountered a very rich ore-shoot known as D 3 (Fig. facing page 216), although only a small part of the shoot is in the Beaver Lake claim, most of it passing into the Keeley. But had Jowsey and Wood found this shoot, the Keeley would undoubtedly have heard about it, and would have worked that part of the shoot which is in the Keeley and which constitutes the largest part. The shoot has proved to be an important producer, and, if it had been discovered in those days, the discovery certainly would have led to an exploration of Wood's vein. Perhaps the rich ore-shoots four or five hundred feet below the surface might have been encountered by Farmers Bank interests, and the bank might have thus been saved from failure. But these are idle speculations. It remained the good fortune of the present company to discover at depth the fabulously rich silver ore of Wood's vein. Such are the vicissitudes, such the tragedy and romance of mining!

The credit for the discovery of Wood's vein must be given to Wood; and although this pioneer and his partners Jowsey and Keeley did not find any ore, they did find flakes of native silver in the vein.

Some of the early history of the Beaver Lake claim is recorded by the inspectors of mines for Ontario and by A. G. Burrows, and their remarks are quoted below.

In 1908, the inspector of mines reported that the following work was done on Beaver Lake claim:—

> The claims H.R. 21 and H.R. 22 are owned by the original owners of the Keeley mine, Messrs Keeley, Jowsey, and Wood, and lie immediately to the west of it. Considerable trenching was done on the two claims during 1908, and veins carrying silver discovered. A shaft has been sunk on it 25 feet, and sinking was to be continued. This vein [Wood's] had a strike of about north and south, and was only a short distance from the west boundary of the Keeley claim.[1]

---

[1] Annual Report, Ont. Bur. Mines, Vol. XVIII, pt. I, 1909, p. 125.

In 1909 the work reported on the Beaver Lake claim, H.R. 21, by the inspector of mines, was as follows:—

> Messrs Jowsey and Wood have been operating on claims H.R. 21 and H.R. 22, lying west of and adjoining the Keeley mine. A shaft has been sunk to a depth of 110 feet, and, on the 75-ft. level, 75 feet of drifting done.[1]

A. G. Burrows, in 1913, has the following remark to make concerning the Beaver Lake claim, H.R. 21:—

> On H.R. 21 there are several calcite veins, and one of these has shown on development native silver. This vein is near the east side line and strikes about north-northeast. A shaft has been sunk to a depth of 110 feet, and on the 75-ft. level, 75 feet of drifting has been done. The gangue is calcite, which has a very fine crypto-crystalline texture, associated in bands with quartz and decomposed material. Leaf silver, in small flakes, has been found in the vein, associated with smaltite, copper pyrites, and native bismuth. Minute crystals of chloanthite are scattered through the gangue.[2]

Veins and Rock Structures

The structure of the rocks and the relation of the veins to the rocks are shown in the drawing facing page 207. The veins occur at the top of the Nipissing diabase sill, both in the sill and in the overlying Keewatin. The top of the sill at No. 3 shaft dips westward at an angle of 34°. Most of the ore has been found along this contact at a depth of 400 to 500 feet below the surface. An important shoot of ore was, however, met with only 55 feet below the surface; this shoot is known as D 3 in Wood's vein. There are also other ore-shoots, 200 or 300 feet above the contact, which are on the whole much lower in grade than those along the contact.

There are five main veins on the Keeley which are worked from the main or No. 3 shaft. The veins at No. 1 shaft, the original discovery, are described elsewhere in this report; they have not been worked by the present company.

The five veins referred to are Wood's, and Nos. 26, 16, 6, and 20. The most important vein is Wood's. The others are branches of this vein. There are several other minor veins.

Wood's, Nos. 26, 16, and 6 are fault veins with displacements up to 30 feet. The writer has not had an opportunity of examining No. 20 vein. The displacement along vein No. 26 is not yet known.

Wood's vein occurs in a reverse fault, having an apparent displacement along the dip of about 30 feet, as nearly as could be ascertained in the present state of development of the mine workings. The horizontal displacement is not known, but the presence of more or less horizontal scratches on the walls of the fault show that some horizontal movement took place. The vein strikes about north and south, and dips eastward at an angle of 65°. The breccia of the fault is not wide, perhaps averaging one to six inches, in places being almost entirely absent. The gouge, too, is narrow, showing only small fractions of an inch in width; in the weathered and oxidized zone the gouge is an inch wide. In places the walls of the fault are schistose. The vein in Wood's fault is, in places, exactly in the fault; that is to say, it abuts against the gouge. In other places the vein is in the hanging wall a foot or two above the gouge; and, in other places, it is in the footwall a foot or two below the gouge. In the same face of the drift, from time to time, veins have been noted in the hanging wall, in the footwall, and in the gouge. In places several irregular veins occur across a width of four or five feet. The breccia of the fault is in places cemented together by vein material, and the veins thus form an irregular network intersecting the fault breccia.

---

[1] Annual Report, Ont. Bur. Mines, Vol. XIX. pt. I, 1910, p. 114.
[2] " " " " " Vol. XIX, pt. II, 1913, p. 143.

It is difficult to say what is the average width of Wood's vein. In places vein matter is almost absent, while in one place on the fourth level the vein has a width of three to four feet. It may average between three inches and a foot in width.

Some replacement of the wall-rock by vein matter has taken place.

Pre-Glacial Weathering

An interesting and unique condition occurs on the south part of the Wood's vein. Pre-glacial weathering has been preserved in this part of the vein (Fig. facing page 216). It has reached a depth of at least 480 feet below the surface. In no other mine in the entire Cobalt area has pre-glacial weathering been preserved, although, as stated elsewhere in this report, good examples are found in connection with ore bodies in other parts of Ontario. There is no absolute proof that the weathering is pre-glacial. It is simply assumed that sufficient time has not elapsed since the retreat of the glaciers to have allowed such deep weathering to form. J. Mackintosh Bell was the first geologist to observe these conditions and he has given the first description of them.[1] For convenience, the term "weathering" may include disintegration, solution, leaching, oxidation, and hydration. The mine workings have penetrated this weathered zone on the third, fourth, fifth, sixth, and seventh levels. The third level penetrated the weathered zone for 600 feet; no indication was there noted that it was becoming less intense at the south end of the drift. The weathering has altered the country rock to a more or less soft clay. In places the clay has a reddish-brown and yellow colour. Elsewhere it has a pale greenish-grey colour. Towards the bottom of the weathered zone, the pale greenish-grey clay is more common than the red clay. That is to say, the red variety of oxidation occurs, for the most part, at and near the surface, and the grey variety occurs, for the most part, at depth.

Judging from chemical analyses and tests made by W. K. McNeill, the red colour of the clay is due to ferric oxide, while the pale greenish-grey colour is due to ferrous oxide.

In places there is a sharp line of demarcation between the red clay and the grey clay; in other places there is a more or less gradual transition between the two. In the case of the sharp line of demarcation, the fault sometimes separates the grey clay from the red.

The alteration of the country rock to clay was noted in one place across a width of six or seven feet. It is, on the average, much less than that.

The zone of contact, which is a very gradual one, between the weathered rock on the south and fresh solid rock on the north, is about vertical.

The writer has been asked the question, whether the weathered zone will extend south to Trout lake, a distance of about half a mile, and whether it will follow along the bottom of Trout lake, a distance of a mile farther south. This can be answered only by exploration of the ground. It is very doubtful, however, if the weathering will persist unless the Wood's or some other fault extends south to Trout lake. The reason that pre-glacial weathering has been preserved is that it followed down Wood's fault along a narrow zone on each side of the fault. Glaciation was not intense enough to remove the solid fresh rock on each side of the fault. Hence the preservation of the weathered zone in Wood's fault.

J. Mackintosh Bell forwarded two samples of ore from the weathered zone of Wood's vein to Ledoux and Company, New York. One of these samples was the red, ferric variety of weathered ore, and the other was the ferrous variety. Ledoux and Company found that the ferrous ore contained a large proportion of metallics, which were principally silver. The sample of ferric ore contained, on the other hand, no metallics.

---

[1] "The Occurrence of Silver Ores in South Lorrain, Ont., Canada," Bulletin, Inst. Min. and Met., February, 1922.

Ledoux and Company's letter, addressed to the Keeley Silver Mines, Limited, regarding these samples, is given below:—

Practically complete analyses have been made on two samples of ore referred to in your letter of December 28, 1922.

The first sample, designated as "ferrous ore," contained a large proportion of metallics which were principally silver. On fine grinding we obtained: Pulp, 91.68 per cent.; Metallics, 8.32 per cent. Since in the ordinary practice of treating this ore. the metallics would be separated in the preliminary stages by ball-mill crushing or otherwise, particular attention has been paid to analysis of the fine pulp, and only the principal elements in the metallics have been determined. Our analysis of the ferrous ore is as follows:—

	Pulp per cent	Metallics per cent.	Composite per cent.
Silica (SiO_2)	43.24	......	39.6
Iron (Fe)	10.33	4.69	9.9
Alumina (Al_2O_3)	12.06	......	11.1
Lime (CaO)	2.42	......	2.2
Magnesia (MgO)	6.92	......	6.3
Manganese Oxide (MnO)	0.68	......	0.6
Arsenic (As)	10.36	10.42	10.4
Antimony (Sb)	0.53	......	0.5
Copper	0.07	......	0.1
Cobalt	0.33	......	0.3
Silver	4.59	73.36	10.3
Sulphur	0.26	......	0.2
Phosphoric Anhydride (P_2O_5)	0.30	......	0.3
Gold	trace	0.06	......
Bismuth	None		
Lead			
Zinc			
Nickel			
Selenium			
Tellurium			

Silver..........3008.5 oz. per ton of 2,000 lbs.
Gold.......... 0.88 oz. per ton " " "

It will be noticed that the elements determined in the pulp account for only 92 per cent. The balance is made up of oxygen combined with some of the iron and with other elements, combined with water as an essential part of the gangue and the alkali metals, potash and soda. The calculation of the composite is on the assumption that the metallics do not contain the constituents of the gangue matter, but of course some gangue constituents are included in the metallics. The metallics consist essentially of native silver, silver arsenides and iron.

The ferric ore developed no metallics on crushing and grinding. Our analysis shows:—

		Per cent.
Manganese Oxide (MnO)		1.33
Silica (SiO_2)		45.46
Iron (Fe)	(Fe_2O_3 15.24)	10.67
Alumina (Al_2O_3)		19.92
Lime (CaO)		1.69
Magnesia (MgO)		3.92
Arsenic (As)		0.38
Antimony (Sb)		Trace
Copper (Cu)		0 06
Cobalt (Co)		0.28
Silver (Ag)	(3.00 oz. per ton of 2,000 lb.)	0.01
Sulphur (S)		0.10
Phosphoric Anhydride (P_2O_5)		0.20
Combined Water		10.47
Gold		Trace

In this sample the iron is present principally as ferric oxide (Fe_2O_3), but an exact determination of the state of oxidation is impossible on account of the presence of arsenic, sulphur and perhaps other oxidizable elements. So far as we can see from the results of our analysis, there is nothing in the ferrous ore that should interfere with ordinary milling operations. While the ferric ore likewise contains nothing deleterious, it contains nothing valuable except a small proportion of cobalt and three ounces of silver per ton. If this is a characteristic sample, we venture to say that the ferric ore should not be included with the ferrous in milling operations.

Secondary Silver

It is generally accepted that most of the native silver at Cobalt is primary.[1] The primary character of all the silver at the Keeley mine, however, is to be doubted. Some of the silver which occurs in the weathered zone, described in preceding pages, is in all probability secondary, as was first pointed out by J. Mackintosh Bell. It would be difficult, nevertheless, to reach a definite conclusion as to what proportion of the silver in the Keeley mine is primary and what proportion is secondary.

This much may be said: In the oxidized zone, native silver in thin leaves has been found deposited on top of red iron oxides. These red iron oxides are secondary; and hence the leaf silver deposited on top of the oxides is also secondary. Very little native silver, however, occurring under this condition has been noted.

Again, soft spongy layers of native silver were noted resting loosely on top of smaltite. The sponge silver could be removed with the nail. This silver is doubtless secondary, having been leached out of the upper greatly oxidized zone and precipitated when the silver solutions came in contact with the unaltered smaltite at depth. Little of such silver was noted.

Probably the ruby silver occurring in geodes and vugs is also secondary. The wire silver, so common at the Keeley mine, is also doubtless secondary.

Beyond these statements, the writer is not prepared to go at the present time. An examination of many polished surfaces of the ore might lead to a more definite idea as to how much silver at the Keeley is primary and how much is secondary

More light may, perhaps, be thrown on this subject when mining operations have reached the bottom of the weathered zone.

W. K. McNeill tested some of the native silver in vein No. 26 on the 480-ft. level for mercury and found it to contain a trace.

DESCRIPTION OF KEELEY MINE WORKINGS

The workings of the Keeley mine may now be described in detail, and if reference is made by the reader to the level plans accompanying this report, the descriptions will be more readily followed.

The workings from the main shaft, No. 3, will first be described, beginning with the bottom level.

Workings from No. 3 Shaft, Keeley Mine

Seventh Level, 480 Feet below Collar of No. 3 Shaft.—There are on the seventh level four productive veins, namely, Wood's; No. 26, which is sometimes called the "Birthday"; No. 16; and No. 20. This level is the richest in the mine.

Wood's is a fault vein, the displacement of which has been worked out on the level above. It dips to the east at 55° to 69° and strikes about north and south. The fault shows very little gouge or fault breccia; the gouge is for the most part but a small fraction of an inch in width, and the fault breccia some two or three inches. In the oxidized zone at the south part of the level the gouge and fault breccia are wider; in places the gouge is an inch and a half in width and the fault breccia six inches in width. Here and there in the gouge, horizontal scratches were observed; other scratches were noted dipping at 10°

---

[1] The Cobalt-Nickel Arsenides and Silver Deposits of Timiskaming, by Willet G. Miller, Ont. Bur. Mines, Vol. XIX, pt. II, 1913, and Guide Book No. 7, Internat. Geol. Congr. 1913, pp. 90-95.

to 15° to the north. Evidently there was some horizontal movement along Wood's vein. In places the fault contains little vein matter. North of the shaft about 80 feet Wood's vein became wider, and early in October, 1922, a high-grade shoot was discovered. Part of this shoot, for a length of 40 feet, assayed from 500 to 14,800 ounces of silver to the ton; one part of the shoot, 12 feet in length, had a width of six to fifteen inches and assayed, according to the returns of the company, 8,000 to 14,800 ounces of silver per ton. This rich shoot was in the hanging wall of the fault about two feet east of the gouge. The writer was fortunate enough to have been at the Keeley mine in October, 1922, when this shoot was discovered, and was therefore able to photograph it (Fig. 44).

At the south part of Wood's vein, a shoot of silver ore was discovered, having a length of 198 feet, which gave an average assay return of 370 ounces of silver per ton across an average width of 19 inches, according to the sampling of the company. This shoot is known as "N" shoot.

In the Keeley mine on the seventh level, there are thus two ore-shoots in the Wood's vein.

In December, 1922, vein No. 26 was discovered. In this vein was found the most consistent shoot of high-grade ore encountered in the mine up to March, 1923. It had a length of 74 feet and, according to the company reports, gave an average assay return of 2,600 ounces across an average width of 15 inches. It is reported by the management that in drifting 74 feet along this shoot the company mined 250,000 ounces of silver; no stoping was done to recover this output. At one place this wonderful shoot had a width of about five feet, but this width was only local and appeared to be due to a sudden swell in the vein, combined with a sharp bend (Fig. 50).

Vein No. 26 is at the south part of the level. It is a branch of Wood's vein and very gradually leaves this vein, almost paralleling it for about 60 feet, at a distance of 2 to 5 feet. Vein 26 then turns to the northwestward, just about the point at which the ore-shoot began to develop. The writer examined the vein on January 24th and 25th, 1923. At that time it showed very little calcite, but was characterized by a high percentage of smaltite, some of which occurred in vuggy, kidney-like, or grape-like rusty masses. The native silver, in places, was noted to occur in thin leaf-like forms in vugs, and on top of the kidney-like or grape-like masses of smaltite. Vein No. 26 appears to occur in a fault of small though unknown displacement.

At the south end of the level, vein No. 20 was discovered early in the year 1923. It is a branch of Wood's vein on the east side and strikes eastward. The writer has not seen this vein, but it is reported to contain high-grade ore, the native silver occurring in "matted" forms.

Vein No. 16 is a branch of Wood's vein. It leaves the latter in a gentle curve and finally strikes westward, about at right angles to Wood's vein. In October 1922, the vein had been followed westward for 225 feet. It is in Nipissing diabase for some distance west of Wood's vein. Where the vein occurs in the diabase it is vertical, but where it enters the Keewatin it dips at an angle of about 60° to the south. This southerly dip is due to the fact that where the vein enters the Keewatin it follows the footwall of a mica-lamprophyre dike and, as the dike dips to the southward at 60°, so the vein also has this dip. It is another instance, so common in the Cobalt area, of a vein following the strike and dip of a lamprophyre dike. In every case, of course, the lamprophyre dikes are younger than the Keewatin, but older than the Nipissing diabase. At the time of our examination in October 1922, vein No. 16 had been traced for 100

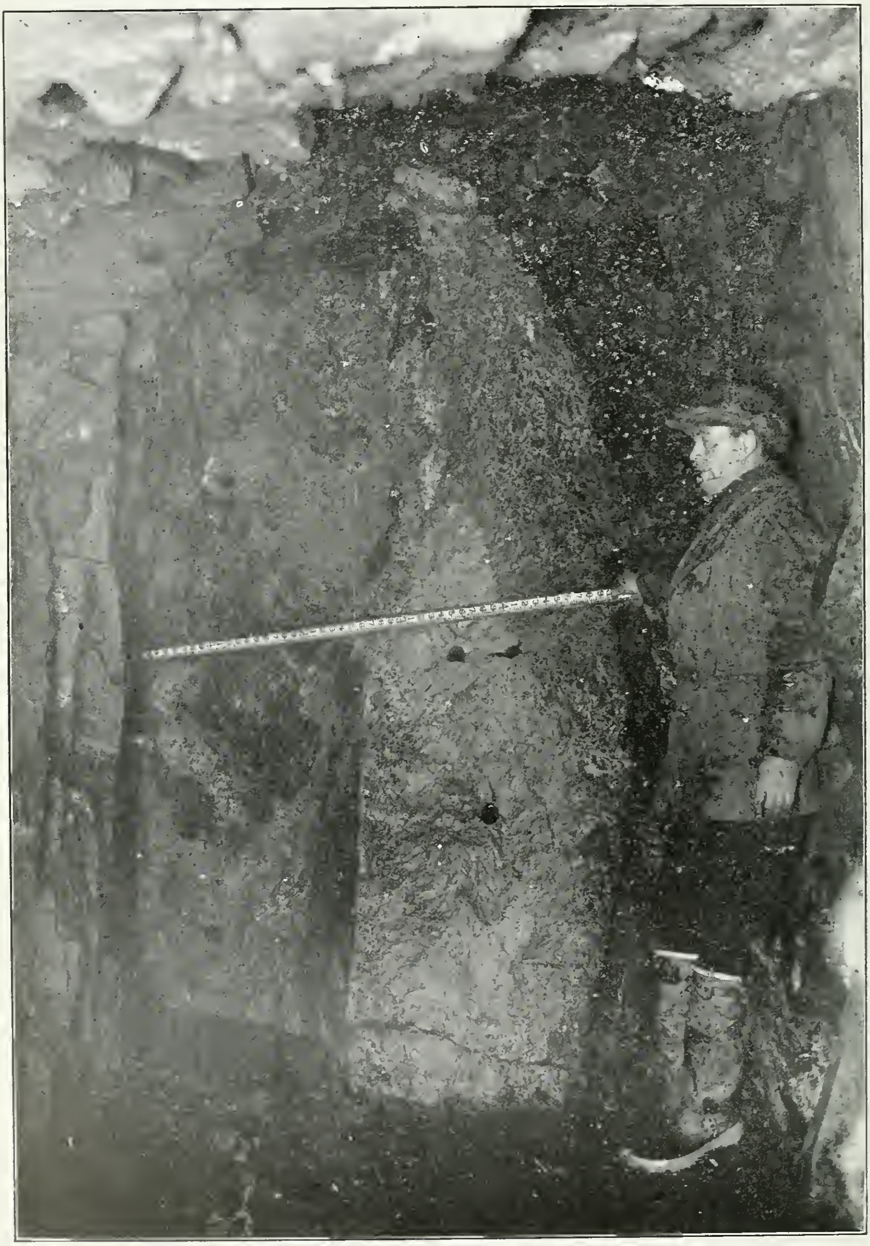


Fig. 50—Keeley mine, vein No. 26, 480-ft. level, January 24th, 1923. The vein is four to five feet wide on this face, but pinches out rapidly to normal size. The ore averages 7,000 ounces of silver per ton. Leonard G. Smith at the right. Photographed by Cyril W. Knight.

feet along the footwall of the lamprophyre dike. Vein No. 16 is a fault vein; it has faulted the contact of the Keewatin and Nipissing diabase about two feet horizontally, the vertical movement not having been ascertained. The fault breccia is six inches wide in places. A stope section along vein No. 16 is shown in the drawing facing page 207.

Weathering and oxidation of Wood's vein and wall-rock first develops about 75 feet south of vein No. 16, where there is a zone of red oxidized material about 15 feet in length. The back of the drift along this 15-ft. zone had soft and dangerous rock, necessitating some timbering. South of this small oxidixed portion weathering almost ceases for about 50 feet, when it again develops, and in places the Nipissing diabase is altered to a more or less soft green clay for a width of at least 4 or 5 feet in places. Most of the oxidized material has a pale greenish-grey colour, although some is coloured reddish-brown due to ferric oxide.

An analysis of the weathered Nipissing diabase at the south part of Wood's vein was made by W. K. McNeill, Provincial Assayer, and T. E. Rothwell. The specimen analyzed was a clayey material having a pale greenish-grey colour; and although the rock minerals were apparently almost entirely altered to kaolin the specimen still preserved its diabase texture.

ANALYSIS OF GREENISH-GREY CLAYEY MATERIAL (ALTERED NIPISSING DIABASE), KEELEY MINE, 480-FT. LEVEL, WOOD'S VEIN, IN OXIDIZED ZONE

	Per cent.
Silica	44.76
Alumina	25.06
Ferrous oxide	5.23
Ferric oxide	5.54
Lime	5.76
Magnesia	3.12
Potash	1.64
Soda	1.44
Carbon dioxide	0.28
Water	7.42
	100.25

Vein No. 26 is stained here and there with red oxides, but the weathering of the wall-rock is not marked.

On levels above, the red oxides of iron are more common in the weathered zone than they are on the seventh, 480-ft. level.

Much water was encountered in certain parts of the oxidized portion of Wood's vein; on October 23rd, 1922, the flow taxed the capacity of the pumps. More water was encountered in the weathered part of Wood's vein on the various levels than was met with in the unweathered portions of the vein at the north part of the workings.

The workings on the seventh level are almost entirely in the Nipissing diabase sill. All of Wood's vein is in the diabase. The Keewatin was met with in the drift along vein No. 16, about 100 feet west of Wood's vein; the Keewatin was also met with in the drift on vein No. 28 west of Wood's vein. The dip of the diabase contact where it occurs in the drift along vein No. 16 is about vertical, but this vertical contact is, presumably, a local irregularity.

Sixth Level, 418 Feet below Collar of No. 3 Shaft.—The productive veins on the sixth level are Wood's, No. 16, and No. 6.

Wood's vein marks the contact between the Nipissing diabase and the Keewatin. In October, 1922, the vein had been drifted on for nearly 700 feet, disclosing Nipissing diabase on the hanging wall, east side, and Keewatin basalt on the footwall, west side, except at the north and where the diabase forms both hanging wall and footwall. The contact of the top of the diabase on the footwall dips, at the north end, at an angle of 10° to the south (drawing facing page 216).

Wood's vein is in a fault. As far as could then be determined, the fault is a reverse one, with a displacement of about 30 feet, more or less, along the plane of the fault (drawing facing page 207). But horizontal scratches on the walls of the fault on the level below show that some horizontal movement has taken place. Sufficient work, however, had not been done to definitely determine the exact displacement, either along the dip or along the strike of the fault.

Wood's vein on this level is, in places, a strong one, showing at one point 12 to 15 inches of smaltite; in other places there is little or no vein matter. At the north part of the drift, the vein apparently leaves the fault for about 50 feet and enters the hanging wall, finally, however, entering the fault again farther north, as shown by the plan of this level. North of this there are vugs in the fault, and some beautiful crystals of argentite and ruby silver were found in these vugs.

The fault breccia varies in width from two to fifteen inches; it will average probably less than three or four inches. The gouge is but small fractions of an inch in width, showing in one place, however, a width of an inch.

Weathering and oxidation along Wood's vein and wall-rock on the sixth level begins about 20 feet south of the crosscut which runs from No. 6 vein to Wood's vein. The oxidation increases in intensity towards the south, until on the face there are three feet or more of soft, brownish-red decomposed rock. In places the hanging wall of Nipissing diabase is completely altered to the soft, clay-like material with a pale, greenish-grey colour, already mentioned, which still retains the diabase texture of the original rock. At the south end of this oxidized zone some very rich lenses of silver ore, a few feet long and one to three or four inches wide, were met with. In this part of the fault there were found lenses of smaltite; and in cracks in the smaltite, there occurred plates of soft, spongy silver. This silver could readily be removed from the smaltite with the finger. Such occurrences of silver, in cracks in the smaltite, are apparently of secondary origin. The silver was probably dissolved out of the upper part of the vein in the oxidized zone and carried down and re-deposited on the smaltite. In this part of the vein there is much wire silver, growing in geodes in the smaltite.

Vein No. 16 is an important one on this level, although it has not yet been so productive on other levels. It leaves Wood's fault in a gentle curve and is evidently a branch of Wood's fault, running at about right angles to it. Immediately west of the fault, a rich shoot was encountered in No. 16 vein. The stope in this shoot is only 30 feet long and 25 feet high, yet it produced about 150,000 ounces of silver. The vein in this stope was in places 12 inches wide of smaltite. The shoot did not extend quite up to Wood's vein, but a small calcite stringer did enter the latter. The vein had been followed west for some distance, and two more shoots of less importance were found (drawing facing page 207). The vein in the drift, west of the rich shoot, is a strong calcite vein showing in places a width of 15 inches. It follows a mica-lamprophyre dike, as on the seventh level. The vein is sometimes on one wall of the dike and sometimes on the other.

Vein No. 16 is evidently a fault vein, as there is about half an inch of fault breccia and gouge in the fissure. On the seventh level the fault has a horizontal displacement of about two feet.

Vein No. 6 is a strong, white calcite vein up to a foot in width, dipping 70° to the east. In places the vein is almost frozen to the walls, while elsewhere there are from one to perhaps three inches of fault breccia and gouge. On the fifth level, 35 feet south of the shaft, a winze was put down on No. 6 vein. In this winze, 17 feet below the fifth level on the east side of the vein, the top of the Nipissing diabase sill was met with; while on the west side of the vein the Nipissing diabase was encountered 19 feet below the fifth level. Thus, vein No. 6 is in a reverse fault which has displaced the diabase contact two feet (drawing facing page 207).

Fifth Level, 355 Feet below Collar of No. 3 Shaft.—Nearly all of the level is in Keewatin, cut by lamprophyre dikes. A little Nipissing diabase occurs at the shaft and in two nearby drifts. Opposite the shaft the contact between the Nipissing diabase and Keewatin is vertical, but this is a local irregularity.

Wood's vein varies in width from an inch or two to about a foot. The fault in which it occurs shows about one to three or four inches of fault breccia and gouge. In places the vein consists of a number of small, irregular stringers which evidently, in part at any rate, replace the wall-rock, which is somewhat schistose. Here and there a lamprophyre dike was noted along the walls of the vein on this level. In places a little pink feldspar occurs in the vein. The south end of the vein and wall-rock is oxidized, the intensity of oxidation increasing towards the south.

Vein No. 16 is a strong vein, up to 18 inches wide, of white calcite; and at one place 30 feet west of Wood's fault, 12 inches of pure smaltite was exposed; some high-grade silver ore also occurred here. The vein follows a mica-lamprophyre dike, as it also does on the two levels below. On the west face there was half an inch of gouge in the fault in which this vein occurs.

No. 6 vein is a strong one, four to six inches wide, having in places a width of 12 to 18 inches of calcite. In places it splits into six parallel stringers. A stope has been worked on this vein.

Fourth Level, 296 Feet below the Collar of No. 2 Shaft.—This level is not connected directly with No. 3 shaft. It is reached by a winze from the third level. The rock consists of Keewatin basalt cut by lamprophyre dikes.

The fourth level had, up to November, 1922, proved to be barren. The work had been done wholly on Wood's vein, the drift on the vein being 550 feet in length. The vein is a strong one, at one point showing four feet of white calcite. It has in places a finely banded texture, due to the interbanding of pink and white calcite, as many as 50 bands or more having been counted across six inches. There is in places a pink, fine-grained variety of calcite in the vein, a sample of which was submitted to W. K. McNeill for analysis, the result of which was as follows:—

ANALYSIS OF FINE-GRAINED, PINK CALCITE, KEELEY MINE, 296-FT. LEVEL

	Per cent.
SiO_2	0.20
MgO	0.16
CaO	53.91
MnO	0.10

The vein is not always in the fault. It leaves the fault at times, and parallels it at a distance of three feet or so in the hanging wall.

The gouge and fault breccia have a combined width of two or three inches.

The south end of the drift is oxidized for 200 feet, the intensity of the oxidation increasing towards the south. On the south face of the drift there is one foot of soft clay, stained brown or yellow; on each side of this clay, the walls are stlll hard but are stained with iron oxides.

Third Level, 235 Feet below the Collar of No. 3 Shaft.—This level is all in the Keewatin basalt, cut by lamprophyre dikes of Haileyburian age. It is one of the most extensive workings in the mine, the Wood's vein having been drifted on for about 1.200 feet. The Wood's vein, as on lower levels, pinches and swells, and is as wide as 15 inches in places.

The south part of Wood's vein and adjacent country rock is oxidized and weathered for 600 feet. Oxidation begins about 125 feet south of the crosscut which goes to the main shaft. The oxidation is at first not marked. It first becomes evident by the appearance, in cracks and joints of wall-rock and vein, of reddish-brown limonite together with the earthy variety of limonite which has a brownish-yellow and ochre-yellow colour. Proceeding south along the drift, this oxidation becomes more intense. The wall-rock gradually turns soft, until finally in places the rock is almost completely decomposed to a soft clay. In some places the rock is altered to this soft material across a width of four feet. The decomposed and oxidized rock, fault breccia, and vein material have for the most part a reddish-brown colour. In places the material has a pale grey colour, tinted with pale green. The lamprophyre dike, which here and there forms the wall-rock of Wood's vein, appears to have weathered more readily than the hard, tough basalt. At one place a sample of this altered lamprophyre was taken and submitted for analysis to W. K. McNeill, Provincial Assayer, and T. E. Rothwell, who found it to have the following composition. It will be noted that the iron occurs almost wholly in the ferric state, Fe_2O_3, probably accounting for the red colour.

ANALYSIS OF REDDISH-BROWN CLAYEY MATERIAL (ALTERED MICA-LAMPROPHYRE DIKE)
KEELEY MINE, 235-FT. LEVEL, WOOD'S VEIN, IN OXIDIZED ZONE

	Per cent.
Silica	44.30
Ferric oxide	13.37
Ferrous oxide	Trace
Alumina	24.19
Lime	1.25
Magnesia	2.24
Soda	0.72
Potash	0.32
Water	12.97
Carbon dioxide	0.90
Total	100.26

Some of the pale greenish-grey clay in the oxidized zone of Wood's vein was tested by W. K. McNeill, who showed that this clay contained the iron largely in the ferrous state, while in the red and brown clay the iron is largely in the ferric state.

In the south part of Wood's vein, there is a stope 175 feet long and 75 feet high in the oxidized portion of the vein. In this stope the width of the oxidized zone varies; in places it is but six inches wide. In December, 1921, a little of the oxidized ore was being treated in the mill, but in November, 1922, none of this material was being used. It is difficult to treat with the present process in use at the mill, and some other method will be adopted for treating it.

In the stope referred to above, there are, here and there, thin films of native silver deposited on top of films of reddish-brown oxide of iron. As these oxides are certainly secondary, it follows that this leaf silver must also be secondary in origin. This secondary silver has probably been leached out from portions of the vein higher up.

Wood's fault near the south end of the drift branches, one branch continuing southward along the general strike of the vein and the other turning and striking southeastward. The southeast branch, judging from the fault breccia, is the stronger fissure. On the south face of this southeast branch, the rock is decomposed across five or six feet to a soft, grey, clay-like material. This branch of the fissure contains a rusty quartz vein one to six inches wide, carrying here and there galena, zinc blende, and iron pyrites. It is curious that some of these sulphides should be perfectly fresh, while the country rock is so much decomposed that it is now altered in places to a soft, clay-like substance. In the fault breccia there is much reddish-brown (ferric) material.

No. 6 vein is in a minor fault, as evidenced by a small gouge and breccia one-half to one inch wide. The vein in this fault may average two or three inches in width, and is as wide as six inches. In places there is no vein material whatever in the fault. The vein and fault breccia are slightly oxidized, beginning about 125 feet south of the shaft. In this part much cobalt bloom occurs along the vein.

Second Level, 164 Feet below the Collar of No. 3 Shaft.—The level is in Keewatin basalt. No. 6 vein is a strong-looking calcite vein one to eight inches wide. It contains some small shoots of smaltite a few feet in length, but carries no silver. No. 6 vein and its branch, No. 9, have been drifted on for 300 feet. No. 6 shows a fault breccia and gouge about half an inch in width. The south end of No. 6 vein and country rock is oxidized for 50 feet. Wood's vein was not worked on this level.

First Level, 100 Feet below Collar of No. 3 Shaft.—This level is in the Keewatin basalt. No. 6 vein and its branch, No. 9, have been worked. No. 6 averages in width from two to three inches of calcite and is wider in places. No. 9 vein is 12 inches in width in places, consisting of calcite; it also shows four inches of smaltite in one place. South of the shaft there is a stope on No. 6 vein about 30 feet long and some 15 feet high. It is reported that one of the old companies obtained a small quantity of silver from this stope. No. 6 vein shows evidence of movement along the wall; there is a fault breccia of about an inch. The vein dips 75° westward, whereas on the sixth level it dips eastward.

Workings from No. 4 Shaft (Beaver Lake)

No. 4 shaft is also called the Beaver Lake shaft, it having been sunk on the Beaver Lake claim, H.R. 21, which is now a part of the Keeley Silver Mines, Limited. The shaft was sunk on Wood's vein and is, therefore, an inclined one, as the vein dips eastward about 65°. There are two levels, namely the 74-ft. level, and the 98-ft. level, known as the intermediate. These two levels are shown on the plan of the third level of the No. 3 shaft. The No. 4 shaft extends down to the third level of the No. 3 shaft.

74-ft. Level.—This is a short level and consists of a drift 120 feet long on Wood's vein. Had the original workers continued the drift a short distance farther north, an important high-grade shoot of ore known as "D3" would have been encountered, although it is largely on the original Keeley claim H.R. 19.

98-ft. (*Intermediate*) *Level.*—This level was run by the present operating company, and on it was encountered the high-grade shoot of ore known as "D3" referred to in the preceding paragraph. The shoot was 60 or 70 feet long and was one of the longest high-grade shoots in Wood's vein. The back of the stope was, at the time of our examination in October, 1922, about 55 feet below the surface (stope section facing page 216).

Workings from No. 1 Shaft, Original Discovery, Keeley Mine

The mine workings from No. 1 shaft are those which were first worked by interests connected with the Farmers Bank. The original discovery was made there by J. W. Wood and R. J. Jowsey. The present company has not attempted to operate these old workings.

On October 28th, 1922, the writer made an examination of these workings. The levels were fortunately all accessible, owing to the fact that the water was kept pumped out for use on the property. The old workings are distinct and separate from the later workings, and have not been connected with the latter. No silver production has come from them since the present company bought the property. Including drifts, crosscuts, and shafts, the length of the workings amounts to some 1,800 feet. They are in Keewatin basalt and Nipissing diabase, the first 168 feet of the shaft being in Keewatin. The top of the Nipissing diabase sill was encountered at this depth, and the work below this, on the third level, was all done in the diabase. The workings show that the contact of the diabase and Keewatin dips at about 28° to the west.

There are three levels, at 61, 131, and 206 feet, respectively, below the collar of the shaft. No stoping was done on the third level. There is a small stope about 25 feet long in Keewatin on the second; and there are four stopes on the first level, the largest of which is about 90 feet in length, all in Keewatin. The first level was the only one of importance as far as production is concerned.

These old workings produced 24,337 ounces of silver, according to the records of the Ontario Department of Mines.

Beginning with the bottom level the following notes may be of interest:—

Third Level, 206 Feet below the Collar of No. 1 Shaft.—The level is entirely in the Nipissing diabase, at the top of the sill The contact between the diabase and Keewatin in the shaft is approximately 38 feet above the level.

There are some twelve veins on the level, consisting of pink and white calcite, barren of silver. They are more or less parallel and strike west 10° to 30° north. The veins are mostly from a half to an inch or two in width; the largest is No. 1 A vein at the shaft which is from a half to four inches in width.

Second Level, 131 Feet below the Collar of No. 1 Shaft.—The west part of the level is in Keewatin, and the east part in Nipissing diabase, the contact dipping 26° westward. Practically all the work has been done on No. 1 vein which, west of the shaft, shows in one place five parallel veins from one-half to three inches in width, one of them showing two inches of smaltite and niccolite. A stope about 25 feet long occurs here. East of the shaft this vein is scarcely more than a pronounced joint crack, showing evidence of a little movement.

At the east end of the workings, No. 8 vein is a fault vein dipping 60° southwest. It carries a little cobalt bloom. The work on the level below had not been, it would seem, carried far enough northeast to encounter this vein.

First Level, 61 Feet below the Collar of No. 1 Shaft.—Most of the silver production came from the first level. It is almost wholly in Keewatin, except about 20 feet at the southeast corner of the workings which is in Nipissing diabase. No. 1 vein at the shaft has a stope about 90 feet long and some 30 feet high, as far as could be ascertained. No. 8 vein at the northeast part of the workings is a fault vein with a dip of 80° to 90° southwest. There are two stopes on this vein, one 20 feet long and the other 15 feet. A vein at right angles to No. 8 vein has a stope about 20 feet long. There are thus four stopes on the first level. The veins, as far as could be seen, vary in width from fractions of an inch to four inches.

Frontier and Crompton

In 1922, the Mining Corporation of Canada, Limited, was working the Frontier and Crompton properties. The number of the Frontier claim is H.R. 16, and that of the Crompton, H.R. 25. The Crompton is a narrow claim, about 500 feet wide, between the Frontier on the north and the Keeley on the south. Both properties are worked from the same shaft, namely, No. 1. In the spring of 1923, however, a new shaft, No. 3, was begun.

The Haileybury Silver Mining Company originally owned H.R. 16. In the year 1909, this company sold the south half of the claim, 20 acres, to the Haileybury Frontier Mining Company. The Mining Corporation of Canada, Limited, subsequently bought the north and south half of H.R. 16, and this claim, H.R. 16, is now generally referred to as the Frontier. The company also owns the Little Keeley, H.S. 40, north of the Frontier, and the Forneri, H.S. 42, north of the Little Keeley. Other claims have been acquired.

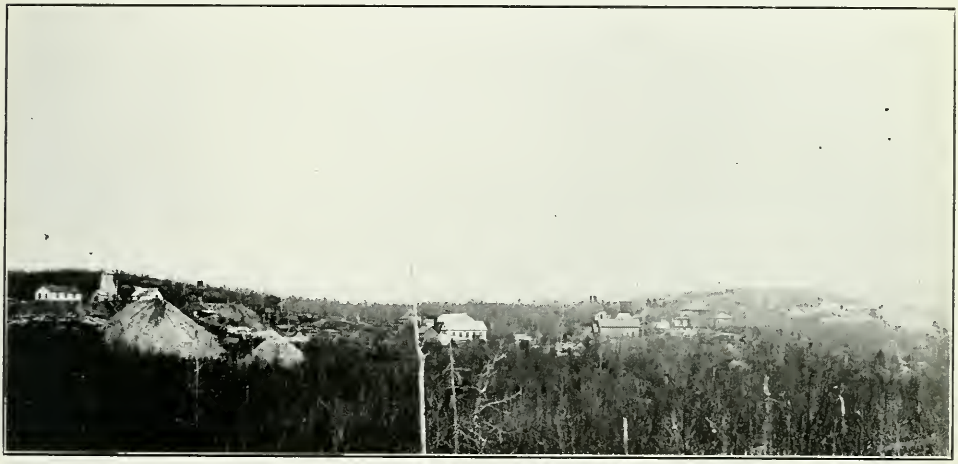


Fig. 51—Frontier mine on left, Keeley mine on right.

Examination of the property was made in the fall of 1921 and 1922, and a brief visit was paid in May, 1923.

The ore-shoots at the Frontier mine, like those at the Keeley, occur at the top of the Nipissing diabase sill, both in the diabase and in the overlying Keewatin.

Almost the entire surface of the Frontier and Crompton is composed of Keewatin basalt, showing in places pillow structure, and volcanic fragmental rocks. The Keewatin is cut by lamprophyre dikes of Haileyburian age. At the southeast corner of the Crompton, the top of the Nipissing diabase sill is exposed. The mine workings prove that the diabase dips under the Keewatin rocks. No. 1 shaft of the Frontier, for example, passes through 322 feet of Keewatin and then encounters the top of the Nipissing diabase sill; the diabase is thus proved to dip under the Keewatin at an angle of about 25° (drawing facing page 219).

There are four main veins on the property, namely, No. 1, the Watson, Wood's, and the Haileybury Silver. Of these veins, Wood's has proved to be the most productive, up to the end of April, 1923.

The mine, referring to the Frontier and Crompton, is worked from No. 1 shaft, and has four levels, which are 75, 150, 300, and 372 feet, respectively, below the collar of the shaft. There is also a shallow shaft, No. 2, on the Wood's vein; and a shaft on the Haileybury Silver vein, now no longer in use.

At the end of April, 1923, fifteen shoots of high-grade silver ore had been met with, two of which were on the Crompton, and the remainder on the Frontier. Three of these were on the second level, but were small and unimportant. The remaining twelve shoots were on the third level; one of them occurred in Wood's vein, another in the Watson vein, and the other ten were in No. 1 vein.

The longest silver shoot was in Wood's vein, at the south end of the Crompton: this shoot had a length of 102 feet and an average height of 35 feet, although it was 57 feet high in one place. The shoot produced to the end of April, 1923, approximately 900,000 ounces of silver, and was the most important ore-shoot in the mine up to that time. At one place the vein was 40 inches wide, of which 36 inches consisted of high-grade, the remaining four inches being calcite. When the writer examined this stope on May 7th, 1923, the vein in the back showed 30 inches of high-grade silver ore in one place (Fig. 52).

Of the other silver shoots one was about 60 feet in length. The shoot in the Watson vein was only 30 feet long and 22 feet high, but it produced approximately 125,000 ounces of silver. Some of the other shoots appeared to have a length of only a few feet.

All of these ore-shoots occur within 100 to 200 feet of the contact between the top of the Nipissing diabase sill and the Keewatin; most of them are within 100 feet of the contact.

The tendency of No. 1 vein to follow a lamprophyre dike may be noted. This dike was observed here and there along the drifts which follow the vein; and on the third level an attempt was made to map it.

Pre-Glacial Weathering

In places the lamprophyre dike referred to in the preceding paragraph is decomposed to a soft clayey material, having a pale, greenish-grey colour. Possibly this alteration is all that now remains of the deep-seated portions of pre-glacial weathering.

Early History of Frontier Mine

As the early history of a mine is always of interest, the writer asked Mr. Horace F. Strong if he would give the Department an account of how he became interested in the Frontier, how he found certain ore-shoots, and how he was instrumental in turning the property over to the Mining Corporation of Canada, Limited. The Department is indebted to Mr. Strong for the following account of the early history:—

> What is now known as the Frontier mine was originally the south half of the property of the Haileybury Silver Mining Company's claim, No. H.R. 16. It contains about twenty acres, and is situated to the north of the Keeley claim and separated from the same by the Crompton fraction. The latter is about 500 feet wide.
>
> One, Henry Newburger, of Memphis, Tenn., bought the south half of H.R. 16 from the Haileybury Silver Mining Company in 1912 for $100,000 cash and formed the Haileybury Frontier Company. This company sank two shafts, one to the southwest to a depth of ninety feet and one near the northern boundary to a depth of 150 feet. From the latter was done about 100 feet of crosscutting and fifty feet of drifting on the 75-foot level, and about 250 feet of drifting on the 150-foot level. Both levels showed a strong vein carrying smaltite, but no silver was in evidence. In the meantime Henry Newburger died and the company went into liquidation in 1914. Joseph Newburger, a cotton king of Memphis, Tenn., and brother of the deceased, bought in the property in the interests of his brother's widow, and the mine remained closed until the autumn of 1920. During the summer of 1920, Joseph Newburger had the mine dewatered and examined by representatives of several silver-mining companies. At this time J. G. Harkness, who had dewatered the mine, had collected options on control of the Haileybury Silver property and advised Mr. Newburger to purchase same. The latter, however, failed to do so and after a couple of weeks allowed the Frontier to fail.

During the autumn of 1919 and spring and summer of 1920, the writer was doing considerable investigation into the various sources of cobalt ore for a large consumer of the metal in the U.S.A., and during a shortage had supplied his client with several carloads of high cobalt, low silver ore. During the month of August, 1920, the situation became so acute that the writer asked his client to be allowed to purchase the Haileybury Silver and Frontier properties, using the argument that several hundred tons of high cobalt, low silver ore could be cheaply developed, with reasonable chances at the same time of running into shoots of high-grade silver ore. The force of the argument was seen, and the writer was allowed to proceed. The Haileybury Silver property was bought outright early in September for $15,000 cash, and negotiations started for the Frontier. The latter proved more difficult, but eventually, in November, 1920, the writer had secured a reasonable lease for a year and further option to purchase. Dewatering was proceeded with immediately, and the first machine started on December 16th. A thorough sampling of the old working showed a short shoot of mill ore on the 75-foot level. Drifting proceeded at the rate of 200 feet per month until May 1st, 1921, and the work put into sight about 400 tons of high cobalt, low silver ore, and two short shoots of 500-ounce silver ore.

Having worked out the geology of the property, the writer prevailed upon his client, the cobalt ore situation being in the meantime settled temporarily, to allow the 150-foot shaft to be sunk to the contact zone. This entailed a further 150 feet of sinking and 27 feet of crosscutting. The sinking was very much retarded by extremely hard rock, the Keewatin greenstone proving very baffling. Eventually the desired horizon was reached about the end of August, and the vein cut within a few inches of the projected point. A short patch of high-grade silver was encountered in the second or third round of the drift, and in 300 feet of drifting, driven during September and October, at least 200,000 ounces in high-grade was indicated. The writer then put two propositions before his client. First, that he should put up an additional $200,000 for the purchase of adjoining properties, install a suitable mining plant, etc., and proceed to develop and mine on a larger scale, or, second, to sell the property. The latter course was decided on, and in November, 1921, the writer concluded the sale under option to the Mining Corporation of Canada, Limited, at a price of $525,000 over a period of two years.

Description of Frontier Mine Workings

Commencing with the bottom level, the mine workings may now be described.

Fourth Level, 372 Feet below Collar of No. 1 Shaft.—This was the bottom level of the Frontier mine in April, 1923. There were about 2,600 feet of workings. The northeast half of the same is in Nipissing diabase, the remainder in Keewatin. The contact between the diabase and Keewatin dips about 15° to the southwest. The Keewatin consists of basalt, cut by lamprophyre dikes of Haileyburian age.

No. 1 vein averages two or three inches in width, swelling in places to 12 or 15 inches. It consists for the most part of pink and white calcite, and strikes southwestward. It contains a few small shoots of almost pure cobalt ore and niccolite, but is barren of silver, excepting for the presence of one small sample. It is wider in the diabase than in the Keewatin. Its contacts with the wall-rock are frozen.

The Watson vein was also barren of silver on this level. It is 2 to 4 inches or more in width and is vertical. A little movement appears to have taken place in the fissure which contains the Watson vein, as shown by a gouge about one-quarter of an inch wide, and a fault breccia an inch or two in width. In places the joint planes, adjacent to the vein, are lightly covered with thin films of red iron oxide. There are vugs in the Watson vein.

Third Level, 300 Feet below Collar of No. 1 Shaft.—This was the most extensive and most productive level in the mine; in April, 1923, there were about 2,850 feet of workings. The Nipissing diabase was met with about 40 feet northeast of the No. 1 shaft. The contact of the diabase and Keewatin occurs in the shaft about 22 feet below the third level. The rest of the level to the southwest is all Keewatin basalt, cut by Haileyburian lamprophyre dikes.

An attempt was made to map an irregular hornblende-lamprophyre dike which appeared parallel to No. 1 vein in the vicinity of the winze. This winze is about 230 feet southwest of No. 1 shaft. The lamprophyre dikes occur in various parts of the level. They are irregular intrusions, difficult to map after the walls have become covered with rock dust following blasting. Some of the dikes are sill-like in form, that is, they have flat dips. Towards the southwest end of No. 1 vein, a lamprophyre dike is decomposed to a soft rock.

The presence of a dike of pink feldspar-porphyry was noted about 60 feet southwest of the winze referred to in the preceding paragraph. Presumably it cuts the lamprophyre, although the relationship was obscure owing to rock dust on the walls and back, and the small exposure.

In No. 1 vein, ten high-grade shoots of silver ore had been met with. The vein is a strong one, in places up to a foot in width, but towards the southwest end, before entering the Watson, it is but an inch or two in width, and in places is little more than a crack. There appears to have been no movement along the crack in which the vein occurs. Little or no gouge or fault breccia was noted.

What appeared to be the longest of these shoots in No. 1 vein occurred about 230 feet southwest of the shaft. A winze was sunk on this shoot, and it was found to extend about 40 feet below the third level. This shoot of high-grade silver ore averaged five or six inches in width on the northeast face of the winze. It was wholly in the Keewatin rocks, and did not extend down to the fourth level where the Nipissing diabase occurred. A small fault, with only fractions of an inch of fault material, intersected the vein, displacing it about an inch. The rich ore occurs above and below the fault. At the time of examination, in the middle of October, 1922, the ore-shoot had not been mined, save for the ore taken out of the winze.

The Watson vein strikes about north and south, bending southwestward at the south end. North of its junction with No. 1 vein, it is a strong calcite vein up to a foot in diameter, and, in places, contains smaltite six inches to a foot in width. This part of the vein is characterized by the presence of many irregular vugs lined in places with arsenides on which have grown calcite crystals. One of these vugs rises at least five feet above the back of the drift, and is six inches wide.

The Watson vein, south of its junction with No. 1 vein, may average an inch or two in width of banded calcite, bulging in places up to five or six inches. The banding consists of alternate layers of pink and grey material, as many as 30 or 40 bands to an inch. About 260 feet south of its junction with No. 1 vein, a wonderfully rich shoot of high-grade silver ore was met with. This shoot is reported to have produced 125,000 ounces of silver, and was only 22 feet high and 30 feet long. In one place it was said to be 23 inches wide. The ore consisted mainly of smaltite and native silver.

To the south of this stope the Watson vein is weak-looking, and along most of the distance is a mere rock. In one place vugs of calcite were noted.

The Watson vein is a fault vein; this is shown by the presence of gouge, small fractions of an inch in width, and a fault breccia of an inch or two in width; in places the fault breccia is wider than this. The displacement along the fault is not known. A lamprophyre dike was noted here and there along the Watson vein; it was not determined whether the dike was continuous along the vein. Pink feldspar was noted in the latter.

Wood's vein is about 300 feet west of the Watson vein, and it strikes about north and south, dipping 65° to the eastward. It is difficult to say what is its average width; in the stope at the south end, described below, it is 40 inches wide in one place, but it is doubtful whether the width of the vein will average more than a few inches along the whole length. It consists mostly of pink and white calcite, in places finely banded. Some pink feldspar occurs here and there. About an eighth of an inch of gouge and three or four inches of fault breccia occur in the fault; in places the fault breccia is wider.

The longest and most important shoot in the mine occurs in Wood's vein at the south end of the workings, near the Keeley boundary line. As stated elsewhere in this report, the stope on this level is 102 feet long with an average height of 35 feet; 900,000 ounces of silver had been mined from the stope to the end of April, 1923. The stope produced some very fine specimens of argentite with wire silver "sprouting" from the argentite. These specimens occurred in vugs in the vein.

A lens of cobalt ore occurs in Wood's vein at the north part of the workings.

On the third level, at the northeast end, two prominent faults occur. The first one is 90 feet north of the shaft, and was drifted on for about 90 feet. It strikes about east and west, and is almost vertical, dipping steeply to the north. This fault has about an eighth to a quarter of an inch of gouge, and six to eight inches of fault breccia. No. 1 vein passes through the fault, and high-grade ore was found north of it, and for a few feet south. At the time of examination a stope was being worked in this ore-shoot, which had reached a height of about 25 feet and a length of about 25 feet.

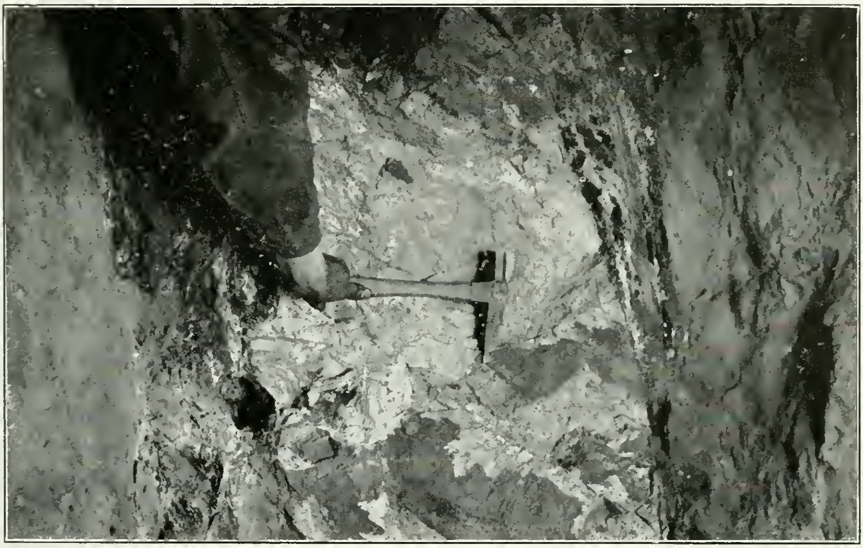


Fig. 52—Wood's vein, Crompton mine, 300-ft. level, back of stope; showing a width of 30 inches of high-grade silver ore. Photograph furnished by the Mining Corporation of Canada, Limited.

At the top of this stope, the second fault, dipping about 34° to the northwest, was met with. This fault had a fault breccia about a foot wide. The vein had not been found above this fault at the time of examination. That the fault was older than the ore deposits appeared to be shown by the presence of leaf silver and ruby silver in the fault breccia, in which these two minerals had evidently been deposited. But there was some later movement which faulted the vein a little. This fault was followed on the level in a drift which begins 50 feet north of the shaft. In this drift the fault breccia is 6 to 24 inches wide. It appears to be an important fault.

Second Level, 150 Feet below the Collar of No. 1 Shaft.—This level is entirely in Keewatin basalt, but is cut by younger dikes of feldspar-porphyry and lamprophyre. Towards the south end of the workings, No. 1 vein appears to follow an irregular lamprophyre dike.

No. 1 vein has been followed for about 1,000 feet, but only three small, unimportant shoots of high-grade silver ore were found. The vein may average two inches, and is five or six inches wide in places, but it is merely a crack elsewhere. At times the vein contains small lenses, five or six inches wide, of cobalt ore.

At the shaft, No. 1 vein encounters a well-defined fault, showing several inches of gouge and breccia, and there is an apparent horizontal displacement of about 30 feet.

At the north end of the workings there is what is known as the Haileybury silver vein. It is a barren pink calcite vein dipping 70° to the northeast. There is a raise or shaft to the surface; some cobalt ore was obtained in the raise years ago.[1]

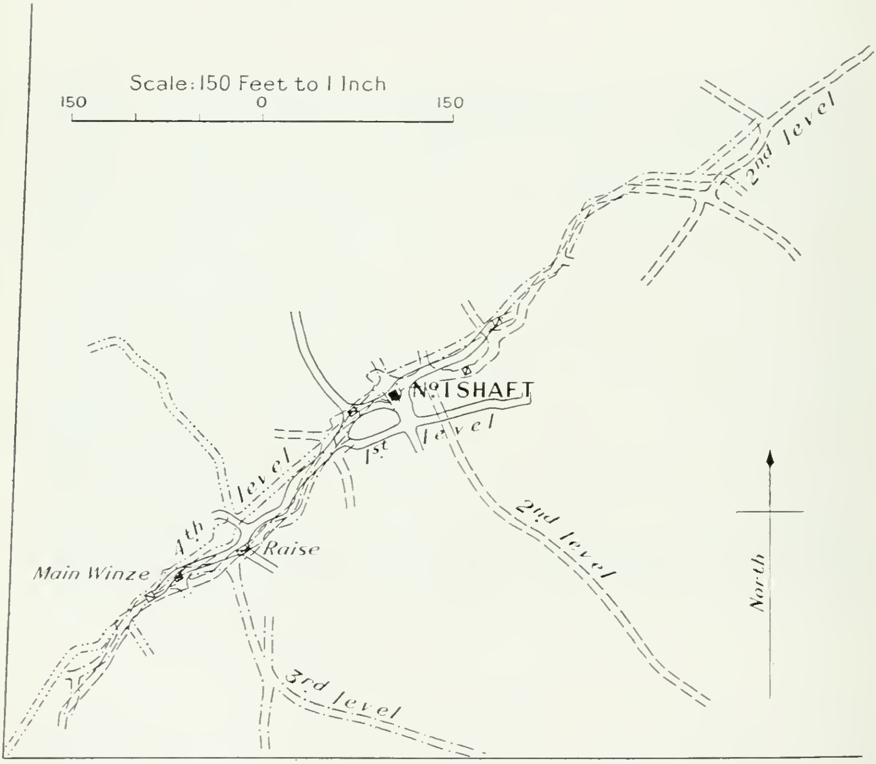


Fig. 53—Plan showing mine workings of Wettlaufer. Furnished by Mr. Horace F. Strong.

First Level, 75 Feet below Collar of No. 1 Shaft.—Only about 250 feet of work has been done on this level, partly on No. 1 vein and partly on a fault which meets the vein not quite at right angles. The vein is about six inches wide and appears to follow a lamprophyre dike. The workings northeast of the shaft were not accessible.

Wettlaufer

The Wettlaufer claim, H.R. 85, is contiguous to the Keeley on the southeast.

The mine had, up to the end of the year 1922, the largest production of silver in South Lorrain, the output amounting to about 2,564,584 ounces at that date. It has not, however, yielded much silver since 1913, although it has been worked on and off since then.

---

[1] The Cobalt-Nickel Arsenides and Silver Deposits of Timiskaming by Willet G. Miller, Annual Report of the Ont. Bur. Mines, 1913, Vol, XIX, pt. II, p. 143.

The property was idle and flooded at the time it was visited in the fall of 1922, and hence it was impossible to examine the mine workings.

From information gathered from various sources, it appears that there is practically one vein on the property. This vein occurs only in the top of the Nipissing diabase sill, and does not extend into the overlying Keewatin, in which respect it differs from veins on the Keeley and Frontier, which occur both in the diabase and overlying Keewatin. One may note on the surface that the vein does not enter the Keewatin.

The Wettlaufer vein strikes about north 60° east. It outcrops along the side of the Wettlaufer valley, and it enters the valley at a gentle angle. The Wettlaufer valley probably represents a fault; and as it strikes north 41° east, it is seen that if the vein continues far enough to the northeast with a strike of north 60° east it would gradually enter the Wettlaufer valley fault.

It is reported that silver occurred on the surface in the Wettlaufer vein. The vein may still be examined on the surface, and in places shows a width of one to three inches of smaltite. Quartz is also found in the vein, stained with cobalt bloom and having a width of two inches.

The vein runs about at right angles to the contact between the Nipissing diabase and the Keewatin.

The writer is indebted to Horace F. Strong, who was manager of the Wettlaufer at one time, for his kindness in writing the following description of the underground geology:—

> The Wettlaufer mine was one of the early discoveries of high-grade silver in the South Lorrain field, and has the unique feature that its comparatively large production came entirely from the Nipissing diabase and from a depth of from 100 feet to 250 feet below the Keewatin contact.
>
> It is essentially a "one-vein" mine, though a branch of the main vein produced ore for a length of 150 feet and a depth of 60 feet.
>
> The main vein runs in width from a fracture up to six inches, and is usually accompanied by two or more parallel fractures from a few inches to two feet away on either or both sides. The strike is northeast-southwest, and the dip is practically vertical.
>
> The channel of mineralization would appear to be a minor reverse fault, striking approximately north and south and dipping to the west at about 20°. At the fourth or 230-ft. level the vein is displaced by a throw of 15 feet. The silver-bearing solutions circulated upward from this fault for a distance of 100 to 150 feet. A few patches of ore were found below the fault, but not more than a maximum of 45 feet below.
>
> In the plane of the vein the ore-shoots rake to the southwest at from 15° to 30°, more or less, conforming with the dip of the contact between the diabase and the overlying Keewatin. At the shaft the contact was, before erosion, about 100 feet above the collar; and high-grade was found in the outcropping of the vein at the shaft. At the southwest corner of the property, 500 feet distant along the strike of the vein, the contact is about 100 feet above the top of the ore zone. This is an interesting feature, and shows a relation between ore zone and contact similar to many cases in Cobalt where the ore zones in the conglomerate of the Cobalt series conform to the Keewatin contact at a more or less regular distance from it.
>
> After the vein leaves the Wettlaufer ground, at the southwest corner, it crosses the northwest corner of the Silver Eagle property, H.R. 97, a length of 20 feet on the fourth, or 230-ft. level, and "feathers" out on the Curry or Pittsburg Lorrain Syndicate property, H.R. 105, in a further fifty feet. Considerable high-grade was taken out of the Silver Eagle, but no ore was found on the H.R. 105 property for more than 20 feet southwest of the line. Northeast of the shaft the vein continues, from two inches to four inches in width, for a further 500 feet, where it weakens, splits into fractures and practically dies out. No ore was found for more than 80 feet beyond the shaft in a northeast direction.
>
> It might be added that the diabase in the vicinity of the vein shows little jointing or fracturing. Consequently, leaf silver penetrated only a few inches into the wall rock, and the quantity of mill-rock from the walls was negligible.

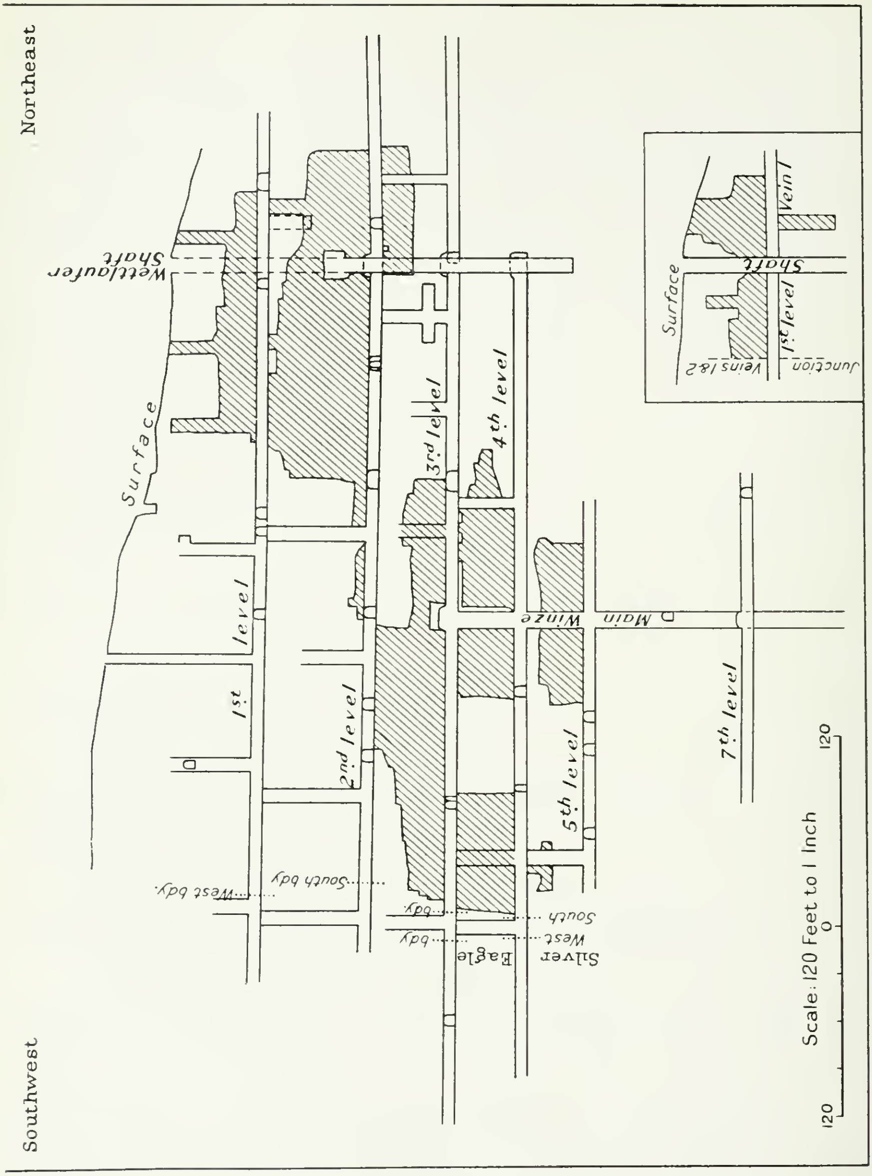


Fig. 54—Stope section of Wettlaufer vein. Furnished by Mr. Horace F. Strong.

Mr. Strong has also very kindly furnished the writer with a stope section of the vein, and with plans of the various levels (Figs. 54 and 53).

A. G. Burrows, who examined the area in 1908 for the Ontario Bureau of Mines, has this to say about the Wettlaufer.—

> On the Wettlaufer claim, H.R. 85, there were found three parallel veins with a strike northeast and southwest. Of these, the two northerly veins had rich shoots showing native silver in sheet form, while the south vein carried smaltite with low silver values. The veins were narrow, but parts of them attained a width of six inches. Flake silver is shot into the diabase wall rock from one to three inches. The distance from the north to south vein is about ninety feet.[1]

---

[1] Annual Report, Ont. Bur. Mines, Vol. XIX, 1913, pt. II, p. 141.

The Ontario Department of Mines is also indebted to J. B. Tyrrell for information concerning the dip of the top of the Nipissing diabase sill in the mine workings of the Wettlaufer. The information was conveyed in the following personal letter to the writer:—

> At that time (1913) five levels had been driven, though I have not a definite record of the depths of the levels, except that the first one was 65 feet below the collar of the shaft. This level was driven westward to the contact of the diabase and Keewatin, and on it the contact was 30 feet farther west than at the surface, making it dip westward at an angle of 64°. The other levels had not reached the plane of this 64° slope or the contact, so that my determination of the slope was taken from these two points.

The inspectors of mines for Ontario have published from time to time the following information concerning the Wettlaufer:—

> In 1908 the following work was accomplished: This claim, H.R. 85, adjoins the Keeley to the southeast. Most of the claim is in diabase, and the vein found runs about at right angles to the contact of the diabase with the Keewatin, and in a northeast and southwest direction. The vein or fissure has been stripped for a considerable distance, and some test pits have been sunk on it. The vein opens up in lenses in places three to four inches in width, carrying good values in silver. A company has been formed known as the Wettlaufer Lorrain Silver Mines, Limited, of which Mr. Wettlaufer is president, Mr. F. C. Loring, managing engineer, and Mr. A. C. Bailey, superintendent.[1]

In 1909 work was done as follows:—

> The Wettlaufer mine is the largest producer in South Lorrain. The main shaft is 150 feet deep, with first level at 65 feet and second level at 140 feet. On the first level, on No. 1 vein, drifts have been run south 190 feet. No. 2 vein is cut by a crosscut from the shaft 79 feet in length. On this vein some 200 feet of drifting has been done. It joins No. 1 vein about 100 feet southwest from the shaft. On the second level the drift southwest from the shaft is 300 feet in length and is driven northeast 175 feet. At a point 75 feet southwest of the shaft a winze is being sunk having a depth at date of inspection of 32 feet. No stoping of any amount has been done.[2]

Regarding operations for the year 1911, the Inspector of Mines reported as follows:—

> The Wettlaufer is the largest and hitherto the only steady producer in South Lorrain. It is owned and operated by the Wettlaufer Lorrain Silver Mines, Limited, which have an authorized capital of 1,500,000 shares of a par value of $1.00, and have paid $450,000 in dividends to June 1st, 1912. On the advent of electric power to the camp from the British Canadian Power Company, a new plant was installed, consisting of a 12-drill compressor, driven by a 200-h. p. motor. A 30-ton concentrating mill has been erected. The main shaft has been sunk to the fourth level, a depth of 250 feet. Levels have been run at depths of 65 feet, 140 feet, 185 feet, and 250 feet. The vein has been developed for a length of 500 feet, the drifts on each level having been run approximately this distance. A winze was sunk at a point 210 feet southwest of the shaft from the fourth to the fifth level, and a drift runs south 160 feet and north 70 feet.[3]

According to the Inspector of Mines, operations carried on in 1912 were the following:—

> The Wettlaufer was the only shipper in South Lorrain during 1912. It is owned and operated by the Wettlaufer Lorrain Silver Mines, Limited. The main shaft has been sunk to the fourth level, a depth of 250 feet. At a point 210 feet southwest of the shaft a winze has been sunk to the seventh level a total depth from the surface of about 500 feet. On the fifth level drifts have been run northeast and southwest of the winze, distances of 70 and 180 feet, and on the seventh level 120 feet and 130 feet respectively. The mill has a capacity of about 30 tons a day.[4]

In 1913, the Wettlaufer operated until October 31st, when it was decided to cease active work at the property. During the year $141,659 were paid in dividends. Some 1,390 feet of drifts, crosscuts, raises, and winzes were run.[5]

---

[1] Annual Report, Ont. Bur. Mines, Vol. XVIII, pt. I, 1909, pp. 124-125.
[2] " " " " " Vol. XIX, pt. I, 1910, pp. 114-115.
[3] " " " " " Vol. XXI, pt. I, 1912, p. 147.
[4] " " " " " Vol. XXII, pt. I, 1913, p. 123.
[5] " " " " " Vol. XXIII, pt. I, 1914, p. 157.

In 1916, the Inspector of Mines reported as follows regarding the Wettlaufer:—

> The Comfort Mining and Leasing Company operated the Wettlaufer property under lease from the Wettlaufer Lorrain Mining Company. Work during the year was confined to milling of fines in the dump and jig tailings from previous milling operations. The tailings were hoisted on an incline and dumped into a raise near the mill, and trammed to the shaft on the 50-ft. level. Work was discontinued during the year.[1]

In August, 1917, the Pittsburgh-Lorrain Syndicate acquired the Wettlaufer mine and mill under lease, and during the autumn of 1917 the Wettlaufer dump was milled. About 750 feet of drifting and crosscutting was done on the third and fourth level, but no new veins were discovered.[2]

In 1918, the Pittsburgh-Lorrain Syndicate operated the Curry and Wettlaufer mines until November 30th, 1918, when work was suspended at both properties. The surface dumps were worked over and a considerable amount of mill-rock was obtained from the underground workings.[3]

In June, 1919, the Pittsburgh-Lorrain Syndicate began to re-treat sand and tailings at the Wettlaufer mill and were handling 20 to 30 tons daily during the autumn. Two small shipments of concentrates were made.[4]

Curry Claim, H.R. 105

The Curry claim is contiguous to the Wettlaufer on the southwest. It was not working at the time it was visited and the mine workings were not accessible. Considerable underground work has been done on the property from an inclined shaft. The Inspector of Mines gives an account of the underground work accomplished, and Horace F. Strong makes reference to the vein and mining operations in his report on the Wettlaufer mine on page 225 of this report. It would appear that the Wettlaufer vein extended about 50 feet into the Curry and then "feathered" out; about 20 feet of the vein on the Curry is reported to have yielded some ore.

On the dump there are pieces of vein matter, showing eight to eleven inches of almost pure smaltite.

About 300 yards southwest of the inclined shaft, there is another shaft sunk in Keewatin rocks. On the dump from this shaft there are pieces of vein matter consisting of fine-grained, banded calcite, or dolomite. The dump also has blocks of diabase, but most of the dump consists of Keewatin basalt.

The following information from the annual reports of the Inspector of Mines is reprinted below.

In reference to operations in 1912 on the Curry, H.R. 105, the Inspector of Mines reported:—

> On H.R. 105, adjoining the Wettlaufer on the southwest, the Pittsburgh-Lorrain Syndicate have been engaged in development work under consulting engineer, J. A. Rice. An inclined shaft has been sunk 271 feet, and a crosscut driven 45 feet to connect with the Wettlaufer workings.[5]

The Inspector of Mines, referring to operations in 1914, reported:—

> The Pittsburgh-Lorrain Syndicate operated this property adjoining the Wettlaufer mine during the year, with a force of 15 to 25 men. The workings consist of a shaft of which the first 200 feet is an incline of about 45° and the next 200 feet is vertical, about 330 feet of raises and winzes and 1,650 feet of drifts and crosscuts. This represents the work done up to November 1st, 1914, in the two years the property has been working.[6]

---

[1] Annual Report, Ont. Bur. Mines, Vol. XXVI, 1917, p. 132.
[2] " " " " " Vol. XXVII, pt. I, 1918, p. 131.
[3] " " " " " Vol. XXVIII, pt. I, 1919, p. 153.
[4] " " " " " Vol. XXIX, pt. I, 1920, p. 110.
[5] " " " " " Vol. XXII, pt. I, 1913, p. 123.
[6] " " " " " Vol. XXIV, pt. I, 1915, p. 129.

The property was worked continuously in 1915 by the Pittsburgh-Lorrain Syndicate. The Inspector of Mines' report was as follows:—

> The shaft has been sunk 275 feet on the slope, the first 175 feet is at 45° and the remaining 100 feet 85°. On the fourth or 175-ft. level a winze was started about 500 feet southeast of the main shaft and was sunk for 115 feet at 80°. Levels were opened off the winze at 50 and 100 feet, and by February, 1916, the drifting done on these winze levels was: on the 50-ft., 50 feet to the northwest and 50 feet to the southeast; on the 100-ft., 20 feet to the northwest and 75 feet to the southeast. A No. 1½ special Sirocco reversible fan is used for ventilating the winze workings. Just above the winze a body of high-grade ore was encountered. The shoot is about 60 feet long; and north of the winze it extends to a known height of 85 feet above this level, while south of the winze it runs for 40 feet above. It is in the Keewatin series just above the Keewatin-diabase contact.[1]

In 1916, the Pittsburgh-Lorrain Syndicate worked the Curry mine continuously during the year. The Inspector of Mines reported as follows:—

> The shaft in the main workings is now 400 feet deep, and work during the year consisted of drifting on the fifth level and raising on the fourth. The winze workings from the fourth level were abandoned. Shaft No. 2 is 110 feet deep, and 500 feet of drifting in the direction of No. 1 shaft was done during the year.[2]

In 1917, the following work at the property was done:—

> Development of the Curry mine, in South Lorrain, was continued during 1917 by the Pittsburgh-Lorrain Syndicate. Some high-grade ore was stoped on the fourth level. In August, 1917, the syndicate acquired the Wettlaufer mine and mill under lease. Operations at the Curry were suspended, and during the autumn of 1917 the Wettlaufer dump was milled. At the Wettlaufer about 750 feet of drifting and crosscutting were done on the third and fourth levels, but no new veins were discovered. Underground work at the Curry mine was resumed and the mill has since been treating Curry ore.[3]

In 1918, the Pittsburgh-Lorrain Syndicate operated the Curry until November 30th, 1918, when work was suspended.[4]

Silver Eagle Claim, H.R. 97

The Silver Eagle is contiguous on the south to the Wettlaufer. Horace F. Strong states that the Wettlaufer vein crossed the northwest corner of the Silver Eagle and that some high-grade ore was mined from this part of the Silver Eagle claim (see report on Wettlaufer by Strong, on page 225 of this report). The claim produced 7,989 ounces of silver in 1918.

Bellellen Claim, R.L. 470

The Bellellen is contiguous to the Little Keeley on the east. It was formerly known as the Newman. The property has produced 31,630 ounces of silver.

It was not pumped out at the time of examination in October, 1922. On the surface most of the rock is Keewatin basalt, but the Nipissing diabase sill is exposed on the southwest part of the claim. The diabase probably dips below the Keewatin, judging from the structure at the Keeley and Frontier mines.

On the dump from the main shaft there are blocks of vein material, showing the vein to have a width of 12 to 15 inches of white calcite. Both smaltite and chloanthite are found in these blocks. The presence of chloanthite was determined by W. K. McNeill, Provincial Assayer. On the dump are blocks of mica-lamprophyre and feldspar-porphyry.

The following information regarding the underground workings is reprinted from the reports of the Inspector of Mines.

---

[1] Annual Report, Ont. Bur. Mines, Vol. XXV, pt. 1, 1916, p. 126.
[2] " " " " " Vol. XXVI, 1917, p. 132.
[3] " " " " " Vol. XXVII, pt. I, 1918, p. 131.
[4] " " " " " Vol. XXVIII, pt. I, 1919, p. 153.

Referring to the year 1909, the following work was done:—

Considerable trenching had formerly been done on this claim. The present owners, under the direction of Norman R. Fisher, have sunk a shaft 75 feet and drifted 100 feet.[1]

In 1911, the following work was done:—

No. 1 shaft is 80 feet deep, with 144 feet and 114 feet of drifting north and south of the shaft on the 80-ft. level; some stoping has been done. No. 2 shaft is 100 feet deep, with 200 feet of drifting and crosscutting at the 100-ft. level.[2]

In 1912, work was done as follows:—

On R.L. 470 the Bellellen Silver Mines, Limited, have been engaged part of the year in carrying on development work. All work is confined to No. 2 shaft, which is 100 feet deep with drifts west 56 feet and south 120 feet. A winze 35 feet deep has been sunk from the south drift, and a drift started north from the bottom of this winze.[3]

In September, 1915, work was resumed on the Bellellen:—

On the 100-ft. level, about 100 feet north of No. 2 shaft, a winze has been sunk 75 feet. On the 40-ft. level of this winze 30 feet of drifting has been done, and at the bottom of the winze a drift extends to the south a distance of 125 feet.[4]

Regarding work accomplished in 1916, it is reported that work was carried on continuously during the year:—

The winze on the 100-ft. level, about 100 feet south of No. 2 shaft, was down 145 feet when inspected in November, 1916. About 75 feet of drifting was done at the bottom level. Shaft No. 1 is 70 feet deep with drifts to north and south at the bottom level. Work during the year was confined to No. 1 shaft.[5]

In 1917, work was continued most of the year:—

The winze on the 100-ft. level was sunk to a depth of 275 feet, and at the 200-ft. winze level a drift was run to the south, a distance of 100 feet.[6]

Maidens Claims, H.R. 69, H.R. 70, H.R. 67, H.R. 66

The Maidens claims are less than half a mile west of Lake Timiskaming. The property was not being worked in the fall of 1922.

There are two shafts about 100 yards apart, and two adits; most of the work has been done on H.R. 69.

On the dump of the most easterly shaft leaf silver was noted; and there were also noted thin films of a black mineral which W. K. McNeill determined to be a sulphantimonide of silver, but the quantity of the mineral obtained was too small for the determination to be absolutely definite. Pieces of the vein on the dump show a width of six to eight inches of calcite and a little quartz. The vein also carries some smaltite. Some of the blocks of vein matter show rock fragments cemented with calcite, suggesting a fault vein; a little cobalt bloom was noted in this fault breccia, and some pure smaltite. Judging from the rock seen on the dump the Nipissing diabase was not encountered in the workings. Blocks of lamprophyre were found on the dump.

The dump from the east adit shows a calcite vein which is over a foot wide in places.

---

[1] Annual Report, Ont. Bur. Mines, Vol. XIX, 1910, pt. I, p. 113-114.
[2] " " " " " Vol. XXI, 1912, pt. I, p. 147.
[3] " " " " " Vol. XXII, 1913, pt. I, p. 123.
[4] " " " " " Vol. XXV, 1916, pt. I, p. 125.
[5] " " " " " Vol. XXVI, 1917, pt. I, p. 132.
[6] " " " " " Vol. XXVII, 1918, pt. I, p. 131.

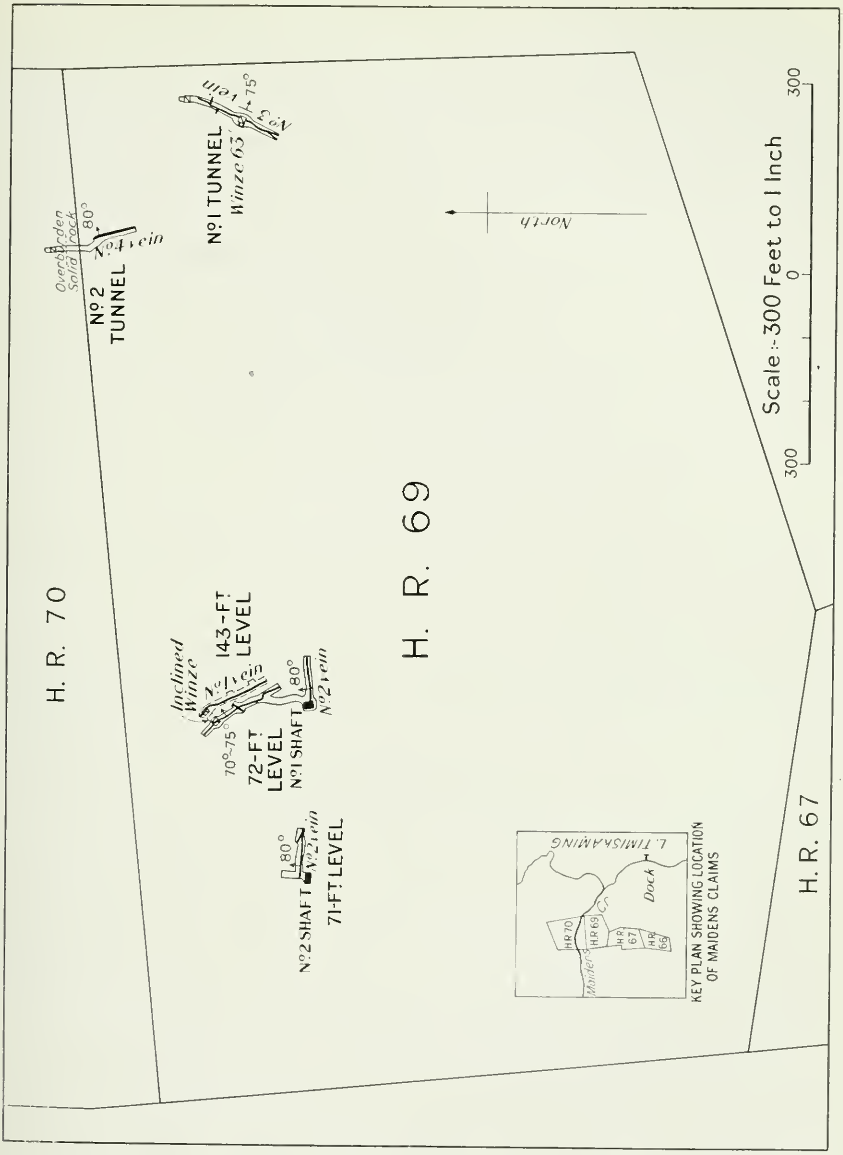


Fig. 55—Plan showing mine workings of Maidens claim, H.R. 69. Furnished by Dr. J. Mackintosh Bell.

On the southeast corner of H.R. 69 the Nipissing diabase is exposed. The rest of the claim is underlaid by Keewatin basalt, although much of the Keewatin is heavily covered with drift. The contact between the Nipissing diabase and Keewatin is drift-covered, so that it is not known whether the Nipissing diabase dips below the Keewatin. It is important to determine how the diabase dips, so that some idea may be obtained as to how far the top of the diabase sill is below the surface in the vicinity of the veins. At the Keeley, Frontier, and Wettlaufer mines, most of the ore has been obtained along the contact, within 100 or 200 feet above or below.

The nearest contact of the Nipissing diabase and the Keewatin is about one mile westward from the Maidens on claims R.L. 461 and H.S. 11. Here the contact is vertical. The contact is also vertical about half a mile to the northwest on claim B.C. 105.

Thus, all that can be said is that the nearest exposed contacts to the Maidens claims are vertical. Diamond-drilling or shaft-sinking will alone determine the dip of the diabase sill on the Maidens claims.

The Keewatin is cut in one place by a hornblende diabase intrusion; it has the appearance of a dike of Haileyburian age.

As the mine workings were not accessible at the time the claims were visited, an examination was not made. The writer is indebted to J. Mackintosh Bell for the following description and accompanying plan (Fig. 55) of the property:—

> Two vertical shafts have been sunk on the property, and two tunnels driven from the surface in the valley of Maidens creek. No. 1 shaft which, including a sump, is 80 feet deep, communicates with a level at 72 feet, from which a winze sunk on the dip of No. 1 vein provides entry to a sub-level 71 feet vertically below. There is an 8-foot sump at the bottom of the winze. Three hundred feet of drifting and crosscutting have been done in the main level, and 125 feet in the sub-level.
>
> No. 2 shaft is 85 feet deep, and 91 feet of crosscutting and drifting have been done from a level of 71 feet. The shaft was commenced on No. 2 vein, which, however, is carried by its northerly dip out of the workings.
>
> No. 1 tunnel driven on No. 3 vein is 162 feet long, and from it a winze reported to be 63 feet deep has been sunk.
>
> No. 2 tunnel, 160 feet long, is a crosscut for 100 feet from the adit, and for the remainder of the distance, 60 feet, is driven on the course of No. 4 vein. The entrance of this tunnel, approximately 40 feet above Lake Timiskaming, has been taken as the datum level. The entrance of No. 1 tunnel is 1.7 feet higher; the collar of No. 1 shaft, 147.6 feet; and the collar of No. 2 shaft, 153.7 feet.
>
> Four strong veins have been so far discovered on the property, all of which have been opened up to a small extent by the developments previously described. In addition, a large number of minor veins have been located in the sub-surface workings, branching from the principal veins.
>
> No. 1 vein, which dips at an angle of about 75° to the northeast, has been opened up for 145 feet in the No. 1 level of No. 1 shaft and for 120 feet in the No. 2 level thereof. The vein, which consists principally of shattered country rock and calcite, contains in places considerable amounts of smaltite and some native silver. It is noteworthy that the silver values which are found both in the vein and the adjoining country rock occur over a greater length and are in general higher at the second than at the first level. The shoot of silver-bearing material has a length of 15 feet at the first level, which assays as follows:—

10 feet from north face	11 ounces	over 48 inches
15 " " " "	8 "	" 54 "
20 " " " "	56 "	" 25 "

> At the second level, irregular values show for a length of 65 feet, measuring southward from the north wall of the sump, as follows:—

North wall of sump	12 inches	52.8 ounces
10 feet	18 "	5.2 "
15 "	30 "	1.6 "
20 "	16 "	1.8 "
25 "	38 "	.8 "
30 "	4 "	12.2 "
35 "	48 "	1.0 "
40 "	16 "	28.0 "
45 "	26 "	79.0 "
50 "	49 "	.2 "
55 "	18 "	.4 "
60 "	31 "	18.4 "
65 "	21 "	.4 "

> No. 2 vein, where it has been developed both in No. 1 and No. 2 shafts (85 feet in the former and 78 feet in the latter) consists almost entirely of soft, highly fractured country rock containing in places some calcite and generally much pyrite. The vein occupies what is clearly a pronounced fault fracture. The strike is easterly, and the dip varies from high angles northerly to high angles southerly, but is generally the former. Wire silver is reported to have been found in the soft vuggy material contained in the vein in the portion now hidden by the shaft timbers.
>
> No. 3 vein is a particularly strong deposit of pink calcite commonly 18 inches or near in width, and containing in many places considerable smaltite. The silver values are low in the portion so far developed. The vein strikes northeasterly and dips 75° to the southeast.
>
> No. 4 vein resembles No. 3 in mineralogical character, but in general it appears to be somewhat weaker. It strikes a little west of north and dips at 80° to the easterly.

In 1913, A. G. Burrows described the Maidens claim in the following words:—

> On H.R. 69, Maidens claim, there has been extensive development work. Near the east side-line a tunnel has been driven from the base of a hill a distance of 285 feet on a calcite vein [No. 3]. At 100 feet a winze has been sunk to a depth of 60 feet. The vein in places has a width of 12 inches. Smaltite and niccolite are found in bunches in the vein. Low silver values are reported to have been obtained on assay. On vein No. 4 to the northwest a tunnel has been driven 225 feet. The vein filling is chiefly calcite with smaltite and niccolite in portions of the vein, 5 to 7 inches in width. The veins are in Keewatin, just north of the contact with the Nipissing diabase, and strike a little east of north.[1]

The inspectors of mines for the Province of Ontario have given in their departmental reports the following information regarding the Maidens claims. In 1908, the work done was as follows:—

> On mining claim H.R. 69, which lies about one mile northwest of the new government dock, the company are doing mining work south of the government road, consisting of adits driven south into the hill, which has an elevation of over 100 feet above the road. No. 1 adit was driven 63 feet through clay to the rock and 135 feet farther, part of it being on the vein which was encountered. Another adit has been begun 300 feet west of the No. 1 and has been driven 50 feet through clay to the rock.[2]

In 1909, the two adits were driven farther into the hill.

> In addition to trenching and test pitting, two adits have been driven, No. 1 having a length of 285 feet and No. 2, 225 feet.[3]

For the year 1914, the report on the property is as follows:—

> The Maidens Silver Mining Company was operating its property during most of the year with a force of six men. A winze was being put down in November about 200 feet from the shaft and had reached a depth of 60 feet below the 75-ft. level. There is another shaft of the same depth, 85 feet, which was not working.[4]

Little Keeley Claim, H.S. 40

The Little Keeley is north of the Frontier. The property was flooded at the time of examination in the fall of 1922. Little underground work has, however, been done, and the records of the Department do not give an account of this work. The rocks on the surface are almost wholly Keewatin basalt.

The property has been acquired by the Mining Corporation of Canada, Limited.

Lorrain Consolidated Claim, H.R. 24

The Lorrain Consolidated, formerly known as the Harris, was not working and was flooded in the fall of 1922. The property is contiguous to the Frontier on the east. A shaft has been sunk to a depth of 263 feet, and 800 feet of drifting and crosscutting done on the bottom level.

On the dump are rocks consisting of Keewatin basalt and of Nipissing diabase. The shaft was begun in Keewatin, and evidently the shaft or other workings passed through this formation into the Nipissing diabase.

Judging from the dump, the workings followed a strong vein; blocks on the dump show the vein to be as wide as one foot, and to contain almost pure smaltite and niccolite six inches wide in places.

The vein has been exposed on the surface by some deep trenches; these have partly fallen in. Where the vein is now seen in the trench, it is from three to six inches in width, consisting of calcite with some pure smaltite and niccolite.

---

[1] Annual Report, Ont. Bur. Mines, Vol. XIX, pt. II, 1913, p. 143.
[2] " " " " " Vol. XVIII, pt. I, 1909, p. 124.
[3] " " " " " Vol. XIX, pt. I, 1910, p. 114.
[4] " " " " " Vol. XXIV, pt. I, 1915, p. 130.

Regarding the work done in 1908, the Inspector of Mines made the following remarks:—

> This claim lying to the east of and adjoining the Haileybury Silver Mining Company property is owned by Mr. Mark Harris. Captain Terrill is in charge of this work and has sunk two pits to a depth of 22 feet and 18 feet respectively.[1]

The work done during the year 1916 is thus summarized by the Inspector of Mines:—

> The Lorrain Consolidated Mining Company, formerly known as the Harris, continued development work at its property in South Lorrain during the year (1916). Work was in charge of J. G. Harkness, on contract; the shaft was sunk to a depth of 263 feet, and about 800 feet of drifting and crosscutting done on the bottom level. It closed down on June 15th, 1917.[2]

Montrose, H.R. 459

The Montrose, R.L. 459, joins the Keeley on the east. A shaft has been sunk to a depth of 110 feet in the Nipissing diabase.[3] On the dump there is a vein of brown weathering calcite or dolomite evidently carrying some ferrous iron.

T.C. 71

Regarding this claim, T.C. 71, A. G. Burrows reported in 1913:—

> On T.C. 71, east of Loon lake, a tunnel has been driven 100 feet on a strong calcite vein about a foot in width.[4]

Taylor Claim, R.L. 471

The Taylor claim adjoins the Bellellen on the north. A. G. Burrows reported in 1913:— .

> On R.L. 471, near the east side line, there is a strong vein of massive smaltite, on which a shaft has been sunk 65 feet. The vein is in the Keewatin.[5]

Alice Lorrain Claim, R.L. 467

The claim is about one-quarter of a mile north of the Bellellen.

The Inspector of Mines reported in 1912 that a shaft had been sunk on the property to a depth of 75 feet.[6] This shaft is in the Nipissing diabase sill at a point about 100 yards east of the contact between the Keewatin and Nipissing diabase. The diabase is the acid variety containing pink spots which consist of a micrographic intergrowth of quartz and pink feldspar. About 125 yards southwest of the shaft, the contact between the Keewatin and diabase is exposed for 40 feet, and the contact may be seen to dip steeply westward.

On the dump, there are pieces of a calcite vein one to six inches wide.

A plant had been erected, but has since been burnt.

Forneri Claim, H.S. 42

The Forneri claim adjoins the Little Keeley on the north, and has been acquired by the Mining Corporation of Canada. It is almost entirely underlain with rocks of the Cobalt series, except at the south end where the Keewatin series outcrops. A specimen from a vein on this claim was submitted to W. K. McNeill, Provincial Assayer, who found that the sample was cobaltite. This vein may be the northward extension of Wood's vein, though this has not been proven as yet.

---

[1] Annual Report, Ont. Bur. Mines, Vol. XVIII, pt. 1, 1909, p. 123.
[2] " " " " " " Vol. XXVI, 1917, p. 133.
[3] " " " " " " Vol. XXI, pt. I, 1912, p. 147.
[4] " " " " " " Vol. XIX, pt. II, 1913, p. 143.
[5] " " " " " " Vol. XIX, pt. II, 1913, p. 143.
[6] " " " " " " Vol. XXI, pt. I, 1912, p. 147.

A. G. Burrows in 1913 reported on this claim as follows:—

> On H.S. 42 (Forneri claim) there is a vein about three inches in width, with strike north-northeast, and occurring in conglomerate. The vein material is smaltite and copper pyrites in calcite and quartz. A surface sample on assay showed no silver values. A shaft has been sunk to a depth of 75 feet. At 35 feet the vein dipped from the shaft. It is reported that silver values were obtained on assay at 14 feet depth.[1]

Sharp Lake Claim, B.C. 100

For the year 1911, the Inspector of Mines reports as follows regarding this claim, which is a mile north of the Forneri:—

> On claim B.C. 100 the Sharp Lake Mines, Limited, have sunk a shaft a depth of 50 feet. At the 50-ft. level a drift has been run south 145 feet and east 60 feet.[2]

H.R. 63

On H.R. 63, on the shore of Lake Timiskaming near Maidens creek, a tunnel has been driven 300 feet into the Nipissing diabase at the foot of a high cliff. The tunnel strikes west 35° south, and was driven to intersect a narrow calcite vein, striking west 32° north, which outcrops about 100 yards south of the portal of the tunnel. The tunnel apparently was not run far enough to reach the vein; at any rate the vein was not encountered. The vein occurs in a joint plane of the diabase along which some horizontal shearing has taken place. The vein is rusty in places. At the end of the tunnel, there is a pink calcite vein from one-quarter of an inch to an inch in width. A horizontal fault, with a little calcite in it, was noted in the tunnel. At the tunnel portal, there is a diabase dike cutting the Nipissing diabase.

H.R. 14

This claim, H.R. 14, is two claims south of the Maidens claim. A. G. Burrows in 1913 reported as follows concerning it:—

> On H.R. 14, near the west side line, some native silver has been obtained in a narrow vein in the diabase.[3]

Tallen Claim, H.R. 106

The Tallen claim is at the northeast corner of Trout lake. The following information concerning the property has been published by the Inspector of Mines:—

> Mr. J. D. Dodd has a contract for sinking a shaft on the property of the Tallen Mining Company, Limited, half a mile southwest of the Curry, in the latter half of the year. Work was started in a prospect shaft 60 feet deep, from the bottom of which 120 feet of drifting had been done. This shaft had a depth of 180 feet on March 1st, 1915.[4]

Regarding operations for the year 1915 and early in 1916, the Inspector of Mines stated:—

> On claim H.R. 106, South Lorrain, the Tallen Mining Company, Limited, has sunk a two-compartment shaft 200 feet.
>
> On the 200-ft. level a drift is being run north 40° west. In February, 1916, the face of this drift was 200 feet from the shaft. Eight men are employed. All the work done in this shaft is in diabase, with the exception of the last 20 feet at the face of the above mentioned drift, which is in Keewatin.[5]

---

[1] Annual Report, Ont. Bur. Mines, Vol. XIX, pt II, 1913, p. 143.
[2] " " " " " Vol. XXI, pt. I, 1912, p. 147.
[3] " " " " " Vol. XIX, pt. II, 1913, p. 143.
[4] " " " " " Vol. XXIV, pt. I, 1915, p. 130.
[5] " " " " " Vol. XXV, pt. I, 1916, p. 126.

A. G. Burrows in 1913 remarked:—

> On H.R. 106, adjoining Trout lake on the northeast, a five by seven shaft has been sunk 50 feet on a calcite vein carrying smaltite.[1]

King George Claims, H.R. 110, H.R. 170

These two claims are at the northeast corner of Trout lake, and are mostly in the bed of this lake.

For the year 1911, the Inspector of Mines reports as follows on the claims:—

> Active development work was carried on during 1911 on claims H.R. 110 and H.R. 170. The main shaft has been sunk to a depth of 272 feet, with 30 feet of crosscutting at the 250-ft. level.[2]

T.C. 73

Claim No. T.C. 73 is about one-quarter of a mile east of Trout lake. In 1913, Mr. A. G. Burrows reported as follows on this claim:—

> On T.C. 73 there is a shaft down 40 feet on a calcite vein with disseminated smaltite and copper pyrites. These veins have not proved to carry appreciable silver values. The rock is the Nipissing diabase.[3]

Toronto Lorrain Claim, H.S. 308

At the north end of H.S. 308, near the shore of Lake Timiskaming, there is a calcite vein exposed at the top of the hill which rises up from the shore. The vein is three or four inches wide and strikes westward, dipping steeply to the north. The vein occurs in banded Keewatin basalt, the banding dipping steeply to the north and the vein following about the dip of the banding of the basalt. A little blasting has been done on this vein. Near the foot of the hill, there is a shaft reported to be about 30 feet deep, following a small calcite vein and an aplite dike. This shaft is in coarse-grained Nipissing diabase. It is some 60 or 70 feet below the vein at the top of the cliff. Further work will show whether these two veins join. The contact between the diabase and the overlying Keewatin is covered on the hillside above the shaft, but is exposed a short distance to the north, where it dips 25° to 30° to the southwestward.

In January, 1923, the Toronto Lorrain Silver Mines, Limited, was organized to take over this claim, together with mining claim No. 19247, surveyed as H.F. 9, and mining claim No. 19389, surveyed as H.R. 123. The president and general manager of the company is Walter J. D. Penly.

H.S. 500

This claim is about one-quarter of a mile southeast of Oxbow lake.

There is a shaft on the property reported to be 38 feet deep in the Keewatin. On the dump beside the shaft, there is a calcite vein about half an inch in width. The shaft is 400 or 500 feet south of the Nipissing diabase. The diabase contact is exposed on the hillside, dipping 37° to 40° southeastward. Some unusually deep trenches have been made on the claim.

H.R. 56

On H.R. 56, which is about one-quarter of a mile south of Loon lake, there is a shaft reported to be about 40 feet deep. The shaft is in Keewatin, and is 100 feet east of the west boundary. There is a vein of calcite an inch or two wide, in places six inches wide.

---

[1] Annual Report, Ont. Bur. Mines, Vol. XIX, pt. II, 1913, p. 143.
[2] " " " " " Vol. XXI, pt. I, 1912, p. 147.
[3] " " " " " Vol. XIX, Part II, 1913, p. 143.

Lang-Caswell

The Lang-Caswell properties, in Lorrain township at the northeast corner of lot 8, in the first concession, were not examined. There is a brief note in the twentieth annual report of the Department which states that:—

> Extensive development work was carried on at the Lang-Caswell properties in Lorrain, and while no ore has been shipped, things are said to look very promising.[1]

Giroux

> On a claim situated on the north shore of Latour lake, concession two, Lorrain township, a shaft has been sunk to a depth of 50 feet and 24 feet of crosscutting done on the 50-ft. level.[2]

---

[1] Annual Report, Ont. Bur. Mines, Vol. XX, pt. I, 1911, p. 54.
[2] " " " " " Vol. XXV, pt. I, 1916, p. 126.

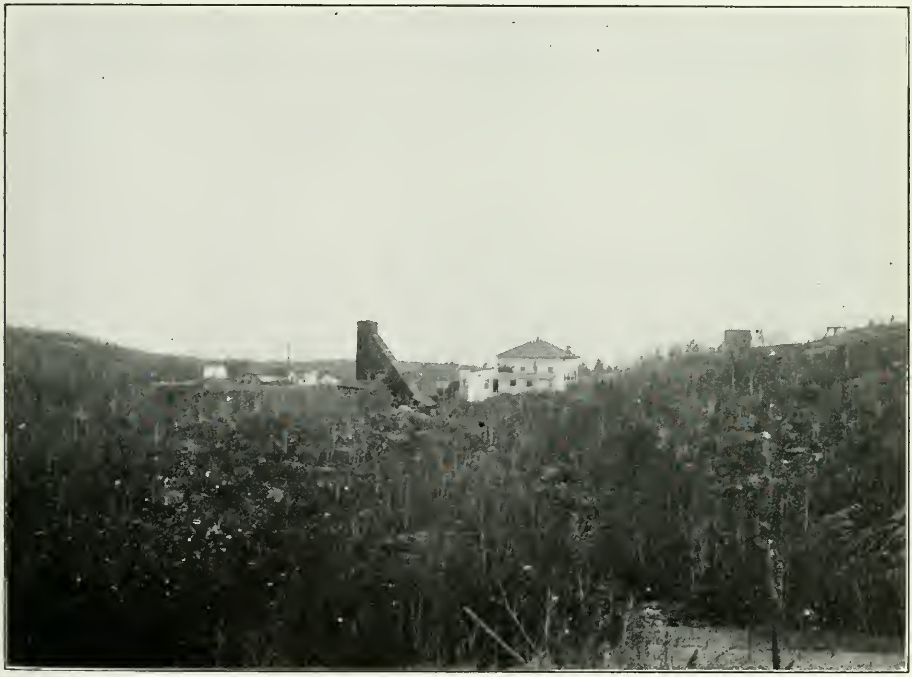


Fig. 56—Old Keeley workings, No. 1 shaft; the original discovery was made in this place.

Lorrain Trout Lake Mines Claim, H.R. 103

In the spring of 1923, this claim was acquired by interests associated with the Mining Corporation of Canada, Limited. Under the direction of this company, work was begun on a shaft which it was planned to sink on the southward extension of Wood's vein. By the end of the year, the shaft had reached a depth of about 350 feet. The results of sampling the vein material in this shaft were published by the Mining Corporation. The assay returns are as follows:—

Channel samples were taken at five foot intervals across the footwall section of the vein. First 35 feet of shaft not on vein.

Depth, Feet	Inches	Ounces per Ton
35	30	8.0
40	16	15.0
45	28	6.0
50	36	65.8
55	38	260.8
60	25	132.2
65	20	72.0
70	19	2214.0
75	18	1155.2
80	20	1017.2
85	20	133.2
90	25	54.5
95	20	....
100	18	28.6
105	20	49.2
110	17	17.0
115	15	11.6
120	18	4.2
125	20	3.8
135	24	5.8
140. . Timbered.	No sample.	
145. . Timbered.	No sample.	
150	54	64.8
155	48	11.6
160	24	29.4
165	36	22.0
170	36	22.8
175	30	23.6
180	36	44.6
185	32	11.0
190	15	22.0
195	12	9.2
200	24	16.8
205	18	77.6
210	12	198.4
215	18	36.0
220	18	72.5
225	4	21.15
230	10	74.0
235	28	48.5
240	16	37.5
245	12	18.5
250	12	25.5
255	12	86.2
260	24	3.0
265	20	6.0
270	21	11.0

AUTHORS' PREFACE TO CHAPTER IV

At the request of Mr. Cyril W. Knight, author of a report on the "Geology and Mine Workings of Cobalt and South Lorrain Silver Areas," the following account has been written of the development of the milling and metallurgical practice in the treatment of the Cobalt silver ores.

For the recovery of silver from these ores, two systems of treatment have been of outstanding importance, namely, gravity concentration, and cyanidation. A third process of relatively minor importance, namely, flotation, was introduced comparatively recently.

The practice used in the different milling plants is largely standardized, although in every mill variations are found in procedure and in the machines used to accomplish a given end. In the following account of the development of the ore-treatment processes, the authors have used the Coniagas mill to illustrate the general practice of gravity concentration and flotation, and the Nipissing mill to illustrate the practice in cyanidation. The practice used in other mills is mentioned, for the most part, only for its historical significance, or because it departs in an interesting and important way from the general practice of the camp.

This plan of development was adopted, after mature consideration, for the following reasons:

(a) The records of these plants were more immediately available and familiar to the authors than were those of similar mills in the camp.

(d) The Coniagas mill is a good example, though no claim is made that it is the best one, of the general standard practice used in gravity concentration and flotation, and well illustrates the various changes and vicissitudes incident to the transition from a high-grade to a low-grade property.

(c) No account is possible of the metallurgy of the Cobalt ores without an extended reference to the work done, and the results achieved, at the Nipissing mills.

(d) This plan of procedure is best adapted to allow of a systematic development of the subject in hand.

In this paper the attempt is made to present a summary of the more important data contained in all previous articles, in addition to much information never before published.

The authors have drawn freely from all printed material on the milling and metallurgical processes of the camp. As far as possible, due acknowledgment for information and data is made by suitable references. A general acknowledgment is here made to cover other cases where a particular reference was not possible.

Fraser D. Reid,
J. J. Denny,
R. H. Hutchison.

Cobalt, March, 1924.

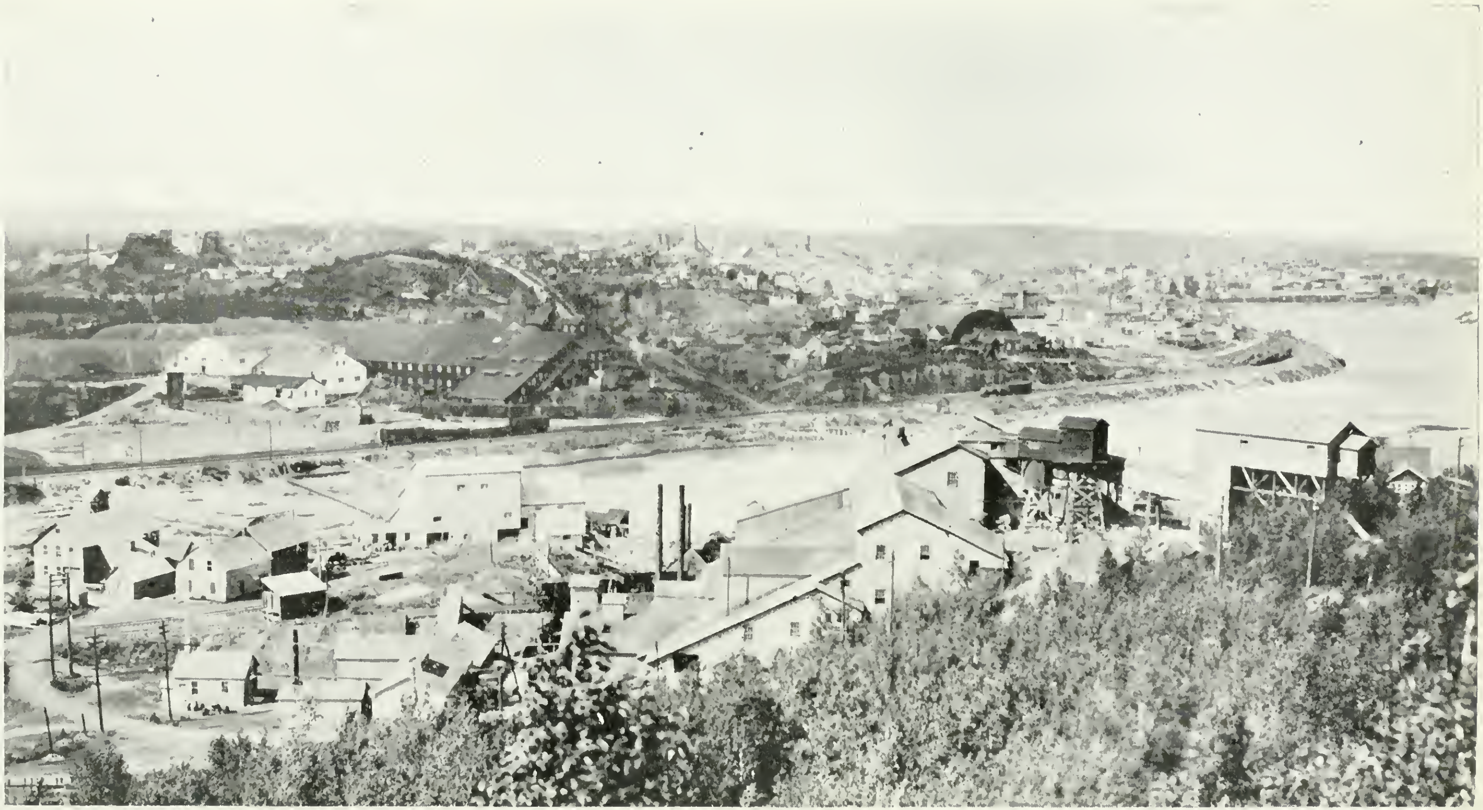


Fig. 57—General view of the town of Cobalt as seen from the hill behind the McKinley-Darragh-Savage mill.

CHAPTER IV

MINING AND METALLURGICAL PRACTICE IN TREATMENT OF SILVER ORES AT COBALT

By

Fraser D. Reid, J. J. Denny, and R. H. Hutchison

SUMMARY OF THE REPORT

The important points in the milling and metallurgical treatment of Cobalt[1] ores are summarized below. These are developed in greater detail in the discussion which follows. (See page 246 *et seq.*)

The Ore

1. The ores of the Cobalt area are a complex assemblage of minerals of which silver, and to a less extent, cobalt and arsenic, are the valuable elements.

2. It is estimated that 97 per cent. of the silver is found in the form of more or less impure native silver. The chief impurity is antimony, together with arsenic and smaller amounts of other elements.

3. The remaining 3 per cent. of the silver is found in various minerals, some of them complex, in which the silver is chemically combined with sulphur, arsenic, antimony, and bismuth. The more important of these minerals are argentite, and the ruby silvers, proustite and pyrargyrite.

4. The valuable minerals have a high specific gravity, and for the most part are readily recovered by standard methods of gravity concentration.

5. The concentrates produced by table concentration and flotation operations are much higher in base-metal sulphides than are the products from jigging and hand-sorting.

6. Gravity concentration will effect a recovery of 80 per cent. of the values from an ore containing 25 ounces of silver to the ton.

7. Early attempts to cyanide the complex ores of Cobalt were unsatisfactory, owing to the heavy consumption of cyanide, the fouling of the working solution, and the prolonged treatment required.

8. The early difficulties were solved by adoption of the practice of fine grinding, by precipitation with aluminium, and later with sodium sulphide, and under some conditions, by a preliminary desulphurizing treatment.

9. Of the various cyanicides present, nickel is the most troublesome in the treatment of high-grade ore and table concentrates. The low-grade wall-rock contains in addition, sulphides of copper and iron that are cyanide-consuming minerals.

---

[1] The reader will bear in mind that the word "Cobalt" when spelled with a capital "C" refers to the area, not the metal.

10. The cyanidation of high-grade ores and table concentrates requires a preliminary treatment for the removal or oxidation of the various cyanicides present.

11. Flotation concentrates, for the most part, cannot be treated locally by cyanidation, owing to the large amount of base-metal cyanicides present.

12. Processes used to recover the silver from the high-grade ore include the amalgamation-cyanidation treatment, the hypochlorite-cyanidation treatment, and the acid-wash cyanidation treatment.

13. Argentite, the ruby silvers, and pure leaf-silver float readily. Antimonial silver, oxidized ores, and cobalt arsenides are floated with difficulty.

Crushers and Crushing

1. The general practice is to use a Blake or jaw crusher as the primary breaker, followed usually by a medium-size gyratory crusher.

2. The use of the gravity stamp as an intermediate crusher predominates throughout the camp.

3. Fine-grinding is done in tube-mills, the present tendency being to substitute iron balls for flint pebbles.

4. The economic limit of crushing is about 16 mesh for gravity concentration, a minus 80-mesh product for flotation, and minus 200-mesh for cyanidation.

Gravity Concentration—Low-Grade Ore

1. The early practice was to give the ore a preliminary washing treatment by jigging and hand-sorting, to recover portions of high-grade vein-matter broken into the mill-rock.

2. Table concentration is effective on sizes from one-quarter inch to minus 200-mesh sands. The sand tables recover a high-grade concentrate, and discharge a low-grade tailing. The fines are treated or re-treated on slime tables.

3. With the introduction of the flotation process, the preliminary washing treatment was discontinued. Coarser battery screens are used, the battery-discharge is given a roughing treatment on sand tables, and classified, the coarser portion being re-ground in tube-mills, with iron balls. The tube-mill discharge after classification is concentrated on slime tables, the tailing from which goes to the flotation plant.

4. The concentrates from the tables are re-cleaned on a separate table.

5. The middling from the re-cleaning table in some cases is re-ground, but usually is returned in closed circuit to the cleaning table.

Cyanidation

1. Cyanidation was first used as an accessory treatment to recover the values in the slime tailing, the first plant to operate being the Buffalo.

2. Concentration followed by re-grinding and cyanidation was first used at the O'Brien mill, where precipitation with aluminium dust was developed.

3. In the early Nipissing practice, the ore below the stamps was treated by straight cyanidation, after a preliminary desulphurizing treatment. Precipitation was with aluminium dust.

4. Sodium sulphide in 1916 was introduced in place of aluminium as the precipitant.

5. Flotation following cyanidation was not successful.

6. The present Nipissing practice is gravity concentration in cyanide solution, followed by cyanidation after extremely fine grinding.

7. The pulp is agitated for 50 hours in tanks provided with mechanical agitators, in a solution containing 0.25 per cent. KCN, with a dilution of 2.5:1. Aeration is effected by means of 6-inch air-lifts.

8. At the Cobalt Reduction Company, 45 per cent. of the feed to mill is rejected as a 40-mesh and finer sand tailing from table concentration. The remaining 55 per cent. is slime which is treated by cyanidation.

9. Extremely fine grinding is essential to dissolution of the silver values in a reasonable time of treatment.

10. Desulphurization is effective only on ores containing considerable amounts of the complex silver minerals, and is not applicable to the general ore of the camp.

11. The precipitate of silver sulphide is desulphurized with aluminium in a solution of caustic soda. It is then melted and refined in a reverberatory furnace and cast into bars.

12. Sampling of wet concentrates, by coning and quartering, gives accurate results.

Flotation

1. The flotation process was adapted to the treatment of Cobalt ores as a result of the work done at the Buffalo experimental plant.

2. Flotation plays a useful part in the treatment of fines, following gravity concentration.

3. The Callow pneumatic system of flotation is used throughout the camp.

4. The oil mixture in general use is 70 per cent. coal tar creosote, 20 per cent. pine oil, and 10 per cent. coal tar. At the Coniagas plant, in order to treat oxidized minerals, the mixture is sulphidized by distilling the oil, under pressure, with sulphur.

5. Grinding is done to 80 or 100 mesh in tube-mills, or Hardinge mills, using iron balls.

6. The concentrate made by the rougher cells is low in grade, containing about 50 ounces of silver to the ton. This is raised to from 400 to 600 ounces to the ton by re-treatment in re-cleaning cells.

7. The tailing from the cleaner cells is the middling. This is either returned to the rougher cell, or is treated in a separate circuit by flotation or cyanidation.

8. The recovery of undissolved mineral from cyanide tailing by flotation was not successful at the Nipissing mine.

9. The attempt to recover the silver from the flotation concentrate by means of a chloridizing roast in Holt-Dern furnaces, followed by an acid salt-leach or by cyanidation, was not a commercial success.

10. Owing to the high cost of marketing flotation concentrates, the production of a high-grade concentrate is essential.

High-Grade Treatment

1. By the amalgamation-cyanidation treatment, 95 to 96 per cent. of the silver was recovered by amalgamating the ore with mercury in a tube-mill. The remaining 5 to 4 per cent. was recovered by agitating the residue from amalgamation for 36 hours in 0.75 per cent. KCN solution.

2. The amalgam was retorted in oil-fired retorts, and the resulting sponge melted and refined in an oil-fired reverberatory furnace.

3. The Thornhill process was used successfully at the Buffalo mill to recover the mercury from the residues. It consisted of leaching the residues with a solution containing 4 per cent. sodium sulphide, which is a solvent for mercuric sulphide.

4. Various means were tried at the Nipissing plant to recover the mercury volatilized during the retorting and refining processes. These included a system of flues, a bag-house, and the Cottrell system of fume precipitation.

Fig. 58—Kerr Lake mine, view of surface plant and dumps.

5. The processes now used to recover the silver from high-grade ore and table concentrates involve a preliminary treatment for the removal or oxidation of base-metal cyanicides, followed by cyanidation.

6. In the hypochlorite treatment, the ore is ground to 200 mesh in tube-mills, using 2-inch iron balls. Calcium hypochlorite is added to the amount of 50 to 75 lbs. per ton of ore. The tube-mill discharge is classified, and the classifier overflow, after settling and decanting, is filtered on Oliver filters, and washed free of chlorides.

7. In the acid-wash treatment, the pulp, after being ground to 200 mesh, is agitated with a 3 per cent. solution of sulphuric acid at a dilution of 2:1. The pulp is washed several times by dilution and decantation, and lime is added to neutralize the acidity.

8. Cyanidation of the pulp is effected by agitating it for 8 to 14 hours with a solution containing 0.5 per cent. KCN, at a dilution of 20-35:1.

9. Both treatments give a recovery of 98 per cent. of the silver.

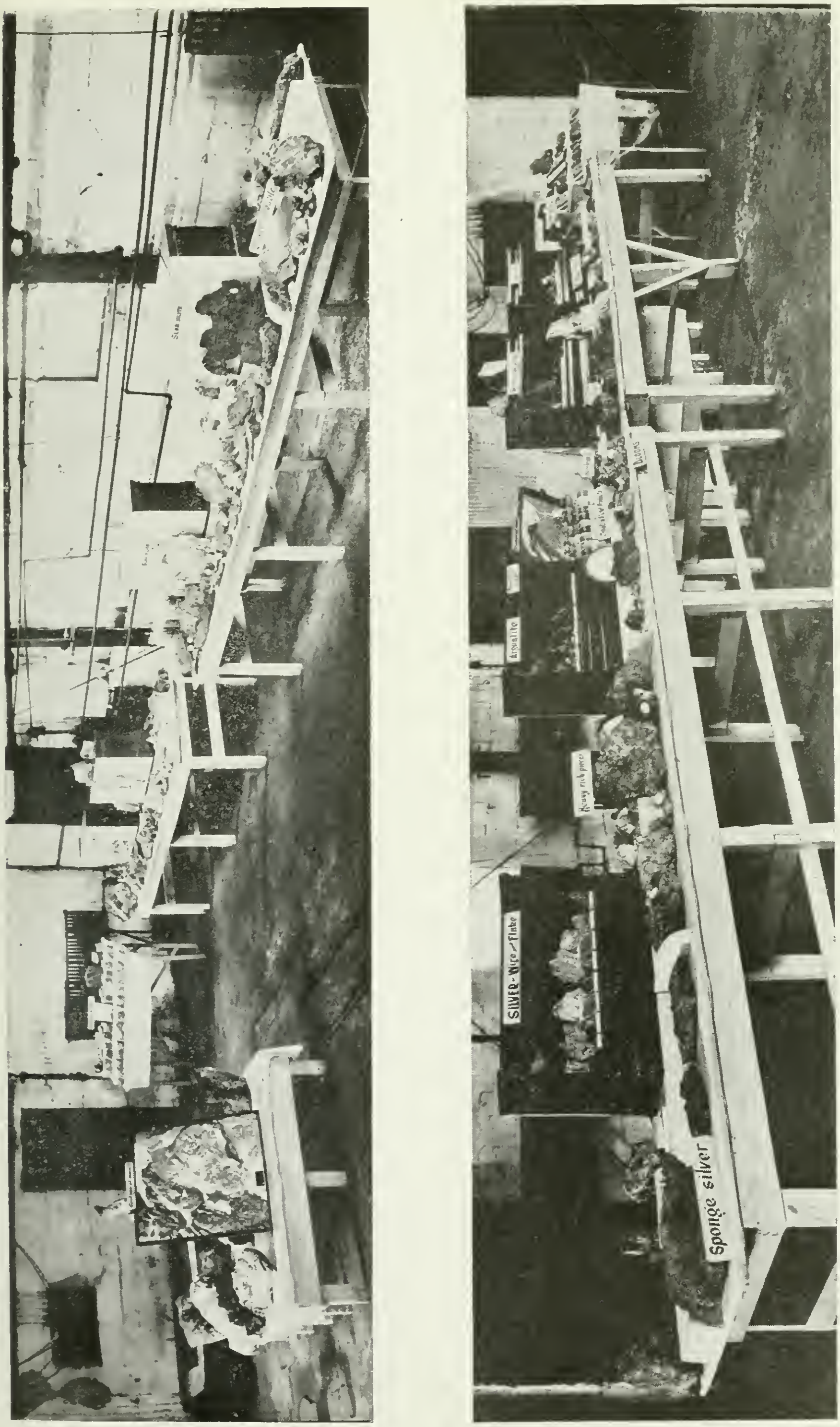


Fig. 59—Minerals of the Cobalt area exhibited at the Nipissing refinery, Cobalt, during the visit of members of the American Institute of Mining and Metallurgical Engineers, August 22 and 23, 1923.

THE SILVER ORES OF COBALT

General Characteristics

The ores of the Cobalt area are remarkable for their high content of silver, and for the complex assemblage of minerals found in the veins and the enclosing wall-rock. The ores include native silver, together with cobalt and nickel, in the form of arsenides, sulphides, sulpharsenides, sulpharsenites, antimonides, sulphantimonides, sulphantimonites, sulphobismuthites, and alteration products. Associated and often intimately mixed with the silver-bearing minerals are found a number of base-metal compounds—smaltite, chloanthite, niccolite, breithauptite, arsenopyrite, cobaltite, native bismuth, millerite, tetrahedrite, chalcopyrite, bornite, emplecite, sphaero-cobaltite, cobalt bloom, annabergite and scorodite, with pyrite, galena, sphalerite, and others. The vein-stones include calcite, together with quartz, dolomite, aragonite, and manganiferous carbonate. Barite and fluorite occur in the outlying areas.

Silver is, of course, the metal of outstanding economic value, but the cobalt and arsenic and, to a less extent, the nickel, are important by-products. Payment also is made on the copper content of certain shipments. A small amount of gold has been found in some veins, associated with cobaltite and arsenopyrite, and in the decomposed vein-matter.

Of the silver-bearing minerals, native silver is of outstanding importance, as fully 97 per cent. of the values occur in this form. It is found in masses ranging from large slabs to the finest filmy leaf. The native silver of Cobalt is relatively impure, containing only from 85 to 96 per cent. of fine silver. The chief impurity is antimony, together with arsenic and mercury. With increasing antimony content, the native silver grades into dyscrasite. In some veins, the native silver is found in plates and leaf, in a calcite gangue; in other veins, it is found associated and intimately mixed with smaltite, niccolite, and breithauptite.

The remaining 3 per cent. of the silver values is found in the numerous, often complex, silver-bearing minerals, in which it is chemically combined with sulphur, arsenic, antimony, and bismuth. Of these compounds argentite is the most abundant and important, followed by proustite and pyrargyrite, together with small amounts of polybasite, freibergite, freieslebenite, stephanite, matildite, etc. These complex silver minerals seem to occur more abundantly in the Keewatin formation, and in the vicinity of the Cobalt fault. Silver is also found intimately mixed with chalcopyrite and bornite. A few decomposed veins are found, carrying a mud which is high in silver, probably as an alteration product from argentite.

Suitability for Gravity Concentration

The valuable minerals have a high specific gravity and, with certain limitations, are readily recovered by standard methods of concentration, even under conditions that are far from favourable. The general practice has been to give the ore a preliminary treatment in washing-plants before sending it to the stamp bins. For the most part, the high-grade vein-matter separates cleanly from the enclosing wall-rock, and is readily recovered by hand-sorting and jigging. The concentrate from this preliminary treatment is clean high-grade ore.

Ores carrying finely divided silver, in a gangue of smaltite and niccolite, concentrate readily, and this type of ore predominates in the camp as a whole. A calcite gangue, on account of its low specific gravity, has a buoyant effect, and such material is more difficult to treat. If, as is usually the case, the silver in a calcite gangue is in plates and larger aggregates, it will usually concentrate readily. On the other hand, silver in the form of filmy leaf is difficult to recover by concentration. The gouge, or oxidized material from decomposed veins, is very difficult to treat by concentration, and since it sometimes runs as high as 12,000 ounces of silver to the ton, it will have a very marked effect on the value of the slime tailing.

The veins vary from a mere crack up to 24 inches in width, and at times a strong vein breaks up into a number of stringers. The vein-matter as far as possible is hand-sorted underground; the wall-rock, together with the stringers and unrecovered vein-matter, constitute the milling-rock. After crushing, the vein-matter liberated from the stringers is recovered by the preliminary treatment in the washing-plant. The rejects from this preliminary treatment, which include the wall-rock and calcite vein-matter carrying fine leaf silver, are sent to mill-bins for further crushing and grinding.

The vein-matter, both from different veins and from the same vein, varies widely in silver content. Thus, calcite veins may vary from barren calcite to vein-matter carrying 5,000 ounces of silver to the ton, while smaltite and niccolite veins range from low-grade or barren smaltite and niccolite to material carrying 8,000 ounces of silver to the ton. A similar irregularity in the distribution of the silver content is found in the wall-rock, which may range from low values to more than 75 ounces of silver to the ton. In general, the wall-rock may be said to average from 10 ounces to 16 ounces of silver to the ton, but this may be raised to 40 ounces or higher by the presence of high-grade vein-matter.

In the wall-rock, the silver-bearing minerals are finely disseminated and associated with larger amounts of pyrite and chalcopyrite than are found in the vein-matter. For this reason, the concentrates from milling operations are much higher in base-metal sulphides than are the jig concentrates or hand-sorted ore. This applies with especial force to the concentrates produced by the flotation process. The high base-metal content of these concentrates has an important bearing on their further treatment for the recovery of silver in a marketable form. Thus it has been found impossible, commercially, to cyanide flotation concentrates where these base metals predominate. These base-metal compounds are more common in the conglomerate and Keewatin wall-rock. The treatment of ores occurring in the diabase gives a clean grade of concentrate, from which the silver can be recovered without difficulty by the cyanide treatment.

The grade of the concentrates varies with the nature of the ore. Thus, where the silver values are evenly distributed throughout the vein-matter, table concentrates are produced which may carry as high as 4,000 ounces of silver to the ton. If, on the other hand, the values are irregularly distributed, the concentrates may contain as little as 500 ounces of silver to the ton, owing to the presence of large amounts of low-grade smaltite and niccolite, together with the base-metal sulphides, pyrite, arsenopyrite, etc.

The losses in the tailing will vary with the character and the grade of the ore. The principal loss is in the fines resulting from the unavoidable sliming of some of the high-grade vein-matter during crushing, and from the presence in the ore of high-grade slime from decomposed veins. The fine filmy leaf silver and various brittle silver minerals, e.g., proustite and pyrargyrite, also slime badly on crushing. As a general average for the camp it may be said that, on treating an ore containing 25 ounces of silver to the ton, a recovery of 80 per cent. of the values can be made by gravity concentration.

Suitability for Cyanidation

Owing to the complex and refractory nature of the Cobalt ores, the earlier attempts to recover the silver by cyanide treatment were disappointing. Using the standard practice of cyaniding silver ores, as then developed, it was soon found that the solution rapidly became foul and lost its dissolving efficiency; that the consumption of cyanide at times was unduly heavy; and that, to get a satisfactory extraction of the silver, a prolonged treatment was required. The solution of these early difficulties, as a result of continued research, has greatly advanced the art of cyaniding complex silver ores and made this method of treating Cobalt ores a commercial success. Some of the more important improvements developed in the Cobalt practice include the recognition of the necessity of fine grinding; the adoption of aluminium and, later, of sodium-sulphide precipitation; the reduction of the complex silver minerals by a preliminary desulphurizing treatment; and the development of processes for the recovery, in the form of bullion, of the silver content of high-grade ore and concentrates, by cyanide treatment.

Cyanicides

Nickel is the predominating cyanicide and is especially troublesome in the extraction of silver from high-grade ore and table concentrates by cyanide treatment. In the treatment of the low-grade wall-rock, copper and iron, occurring as base-metal sulphides, together with other compounds, account for most of the cyanide consumed.

The cleanest ore from the standpoint of cyanide treatment is native silver in a calcite gangue. Table concentrates contain a certain amount of base-metal sulphides, and are more difficult to treat than high-grade ore and jig concentrates. In flotation concentrates, excepting only those produced by the treatment of ores occurring in the diabase, these base-metal compounds predominate, and on account of the heavy consumption of cyanide they cannot be treated by cyanidation.

The various processes for the treatment of high-grade ore and concentrates by cyanidation usually involve a preliminary treatment for the removal of these cyanide-consuming elements.

The effect of the different cyanicides is well illustrated by the results of the following test:—

The Ore.—A sample of niccolite and smaltite, containing a trace of silver, together with various base-metals.

Treatment.—The sample was ground with flint pebbles, in a small Abbé mill, to pass a 200-mesh screen. It was then given a cyanidation treatment in a two-liter bottle, with agitation on a wheel.

TABLE I.—DETAILS OF CYANIDE TREATMENT

Weight of ore	50 grammes.
Time of treatment	24 hours.
Dilution of pulp at finish	24:1 (by weight).
Lime added per ton of ore	10 lbs.
Strength of cyanide maintained at 0.5 per cent. KCN.	
After treatment the cyanide consumed, per ton of ore	1077.3 lbs. NaCN.

ANALYSIS OF SOLUTION AFTER CYANIDE TREATMENT

Element	Per cent. in solution	Amount of metal in lbs. per ton of ore	NaCN tied up, lbs. per ton of ore
Fe....................	0.046	32.08	116.18
Cu....................	Nil	Nil	Nil
Zn....................	0.090	43.20	129.56
Ni....................	0.470	225.60	754.72
Co....................	0.020	9.60	47.90
NaCNS........	0.038	18.24	18.24
As.......	0.408	195.84	.. ..
			1066.60

Comments

1. Assuming that the metals are present as double cyanides, the percentages of these elements in the solution would account for a total cyanide consumption of 1066.6 pounds. The test showed a real consumption of 1077.3 pounds NaCN, the difference of 10.7 pounds being unaccounted for.

2. The above sample is not representative of the high-grade ore being treated by the cyanide process, since it contains a considerable amount of zinc and only a trace of silver. The test, however, does indicate very clearly the fact that the nickel compounds are the predominating cyanicides.

Cyaniding Low-Grade Ore

Owing to the good results obtained by straight concentration, and the difficulties experienced in the earlier attempts at cyaniding, the dumps and low-grade ore were at first treated exclusively by concentration, and the concentrates sold to the smelters. Later, certain of these mills added a cyanide annex to treat the slime tailings, the lower-grade sands going to waste. Later still at the O'Brien mill, after a preliminary concentration on tables, which recovered 40 per cent. of the silver as a high-grade concentrate, the ore was crushed to 80 per cent. through a 200-mesh screen, and the remaining values extracted by cyanide treatment, using aluminium-dust precipitation. The Nipissing low-grade plant was the first mill to treat the ore by an all-cyanide process below the stamps. From time to time, various changes were made in all of these plants to bring the treatment into line with the newer developments in practice, and to adapt the process to changing conditions in the nature and grade of the ore, changes in marketing conditions, and changes in the cost of materials, as a result of the dislocation of industry by the Great War.

The fouling of the working-solution, with the consequent loss of dissolving efficiency, was found to be due to the introduction of zinc into a solution carrying considerable amounts of dissolved arsenic and antimony. This was corrected by substituting aluminium for zinc as the precipitant, since aluminium forms no compounds with cyanide. The use of aluminium also effected an important saving in cyanide consumption.

Clean native silver in a calcite gangue dissolves readily in cyanide solution, giving a high extraction, as do also the filmy brittle leaf and the high-grade slime from decomposed veins. On the other hand, impure native silver, high in antimony and grading into dyscrasite, dissolves very slowly and requires a prolonged treatment. Of the silver compounds, argentite yields to treatment without difficulty, but with proustite and pyrargyrite the extraction is low, and when these minerals are present in the ore, the tailing from the cyanide treatment is relatively high.

Owing to the refractory nature of these minerals, extremely fine grinding is essential to dissolution, in order to obtain a satisfactory extraction within a reasonable time of treatment. Failure to recognize this fact was responsible for much of the 'grief' and unsatisfactory results of the earlier operators. In the present practice of the Nipissing low-grade mill, the 200-mesh sands are ground to a true slime by means of iron balls in tube-mills, operating in closed circuit with Dorr bowl classifiers.

The extraction of the silver from the complex silver minerals is, for the most part, greatly improved by giving the ore a preliminary desulphurizing treatment with aluminium in a solution of caustic soda, before sending it to the cyanide tanks. By this treatment these minerals are reduced to their elements, leaving the silver as a spongy metal, in which condition it is readily soluble in cyanide solutions. As these silver minerals are not characteristic of the ore as a whole, but rather are found localized in certain veins and sections of veins, this preliminary desulphurizing treatment is not applicable to the general ore of the camp.

Cyanide in Treatment of High-Grade Ore and Concentrates

The advantages of shipping only fine bullion led to the development of various processes for the local treatment of high-grade material, but more especially hand-sorted ore and jig and table concentrates. The processes involving the use of cyanide for the extraction of the silver include the following:

(*a*) *The Amalgamation and Cyanidation Process.*—This was used at the Nipissing high-grade mill and later at the Buffalo mill. Pan amalgamation was also used at the Dominion Reduction plant. In this treatment cyanide played a very subordinate part. In the Nipissing practice an extraction of 97 per cent. of the silver was obtained by amalgamation in the tube-mill, leaving an extraction of only 3 per cent. for the cyanide process.

(*b*) *The Hypochlorite-Cyanidation Process.*—This process was developed by the joint efforts of the Cobalt Reduction and Nipissing Mines, and is still in use at the Cobalt Reduction plant. At the Nipissing it replaced the older amalgamation process, owing, among other reasons, to the increased cost of mercury. The process involves the oxidation of the base-metal compounds by a preliminary treatment of the ore with hypochlorite, before sending it to the cyanide tanks. An extraction of 97 per cent. of the silver in the ore in the form of fine bullion is effected in a treatment period of ninety-six hours.

(*c*) *The Sulphuric Acid-Cyanidation Process.*—This was introduced at the Nipissing high-grade mill where it has replaced the former hypochlorite treatment. It involves the removal, before cyanidation, of the decomposed nickel compounds by a preliminary treatment with dilute sulphuric acid. The results are similar to those from the hypochlorite treatment, but on decomposed material a greater saving in cyanide is effected.

(*d*) *Chloridizing Roast.*—This process was used at the Buffalo mill for the treatment of flotation concentrates. It consisted of a preliminary chloridizing roast in the Holt-Dern furnace, followed by a weak acid-wash to eliminate the cyanicides, especially copper, after which the pulp was treated by cyanidation.

Suitability for Flotation

In the enthusiasm that followed the introduction of the flotation process, high hopes were entertained as to the possiblities of this method of concentrating Cobalt silver ores. Indeed, the many advantages claimed for the new process, such as its high efficiency, low treatment costs, and inexpensive installation, led some of its exponents to hope that it would displace entirely the older methods of treatment by gravity concentration or cyanidation, and completely revolutionize the established practice of ore treatment. But these hopes have largely failed of realization. The flotation process is not so efficient in the treatment of Cobalt ores as was at first anticipated. As against the cyanide process, flotation produces only a concentrate instead of fine bullion. As against gravity concentration, the flotation concentrate is expensive to market: it is relatively low in silver and high in silica; it is high in base-metal sulphides and low in cobalt arsenides, and the latter are now valuable by-products. For these reasons flotation concentrates are not desired by the Canadian smelters. At the present time they are marketed in the United States.

The various minerals in the ore respond differently to the flotation treatment. Thus fine leaf silver floats readily, as do also argentite, and the ruby silvers, proustite and pyrargyrite. Antimonial silver and dyscrasite, and the silver in the high-grade slimes from oxidized veins, are recovered less readily. The base-metal sulphides are raised easily, but the arsenides are floated with difficulty.

The result of the flotation treatment on some of the more important silver minerals in the Cobalt ores is shown in the following table:—

TABLE II.—RESULT OF FLOTATION TREATMENT ON SILVER MINERALS

Mineral	Head assay	Tail assay	Concentrate assay	Extraction
	oz. Ag.	oz. Ag.	oz. Ag.	per cent.
Silver (native silver minus 100 plus 200 mesh)	15.56	12.20	482.00	22.23
Silver (native silver minus 200 mesh)	20.48	6.00	1377.00	71.04
Silver (refined silver minus 100 plus 200 mesh)	12.53	3.30	512.00	74.14
Silver (refined silver minus 200 mesh)	15.67	2.70	632.00	83.15
Argentite	30.41	8.85	1972.43	71.22
Proustite	19.75	7.62	1824.97	61.82
Pyrargyrite	33.33	8.64	1524.52	74.49
Matildite	22.05	14.03	973.57	36.91
Freieslebenite	9.63	4.96	421.55	49.15
Freiburgite	19.99	4.52	534.25	78.03

Comments

1. Samples for the above tests were prepared by adding picked specimens of these minerals to a sand-tailing containing approximately 3.5 ounces of silver to the ton. The sample was then ground dry, to pass a 100-mesh screen, with flint pebbles in an Abbé mill.

2. Testing was done by treating samples of 1000 grammes for thirty minutes in a mechanical frothing machine, at a dilution of 4:1. An oil mixture, containing 70 per cent. creosote, 10 per cent. coal tar, and 20 per cent. pine oil, was added to the amount of one and a half pounds per ton of ore.

3. The effort was made to produce a high-grade concentrate and a tailing in one operation.

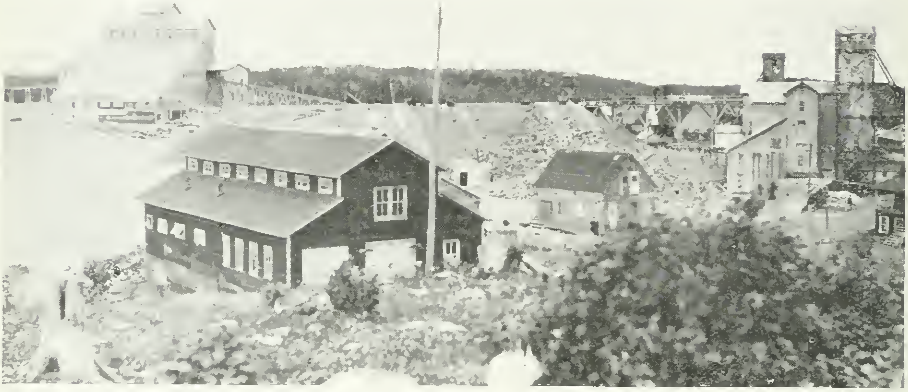


Fig. 60—Temiskaming mill and shaft-house.

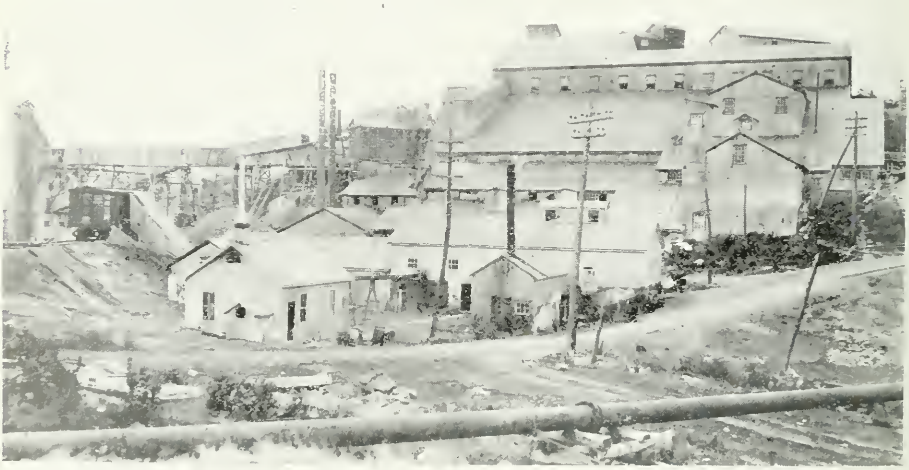


Fig. 61—McKinley-Darragh-Savage mill.

CRUSHERS AND CRUSHING

Introduction

Every mining camp presents many problems that are peculiar to itself, the solution of which will depend on the particular conditions prevailing in the district. This applies as much to the crushing of the ore from any camp as to the mining or metallurgical treatment of it. Each is a problem to be solved on its own merits. For this reason, it is unsafe to indulge in broad generalizations and to attempt to impose the solution of such a problem for one region, under a given set of conditions, on another region where the conditions are entirely different.

The crushing practice of the Cobalt area, arrived at by a process of trial and elimination, represents the best solution of that problem for this district, under the conditions imposed. Some of these governing conditions are the low tonnages treated, the hardness and toughness of the rock, the richness of the ore, and the desirability of sliming or non-sliming.

Coarse Crushing

For these reasons, the Blake or jaw crusher is favoured as the primary breaker, owing to the ability of a medium-size machine of this type to take the run-of-mine ore, and break it to 2-inch to 4-inch cubes. A breaker of the gyratory type, capable of handling the larger pieces of rock, would be out of all proportion to the capacity of the rest of the mill. A medium-size gyratory is generally used as a secondary crusher, discharging a product of 1 inch to 2 inches.

Intermediate Crushing

With Cobalt ores stage-crushing followed by concentration is not practicable. After the preliminary hand-sorting and jigging treatment, approximately 70 per cent. of the values are liberated on reducing the ore to 16-20 mesh. This will permit the elimination of a sand tailing carrying three to four ounces of silver to the ton. For gravity concentration, sliming of the valuable minerals should be reduced to a minimum. The work of the intermediate crusher, therefore, is to reduce a feed of 1 inch to 2 inches to 16-20 mesh, in one operation, with a minimum production of fines. For this purpose at some time or other, practically all the standard machines have been tried out in the camp. These include gravity stamps, rolls, the Huntingdon mill, the Chilian mill, the Symons disc, the Hardinge mill, and various types of ball-mills: the Krupp, Gates, Chalmers, and Marcy, as well as combination ball-and-pebble mills. These machines were used with varying degrees of success. A comparison of their performance is impossible for various reasons, one of which is that the conditions under which they were used were not always parallel. In the ball-mills and tube-mills, all the standard liners have been tried. The present practice is to use liners of manganese steel in the ball-mills for coarse crushing, and chilled iron in the tube-mills for fine grinding.

Gravity Stamp Best for Intermediate Crushing

As an intermediate crusher, however, the gravity stamp has proved its superiority over all other types and combinations of machines. The smashing blow of the stamp is particularly effective in reducing the tough Cobalt rock to a granular product with a minimum of slime, which is very suitable for table concentration. It is therefore no accident that the use of this machine has always predominated in the camp and that at the present time all the ore being treated is crushed in stamp batteries.

The stamp has won its present position of popularity in the Cobalt camp on its merits as an intermediate crusher. Some of its advantages may be summarized as follows:—

1. Its efficiency and low operating cost.
2. Its simplicity and reliability.
3. The stamp as a unit is the same for a small mill as for a large mill. For this reason the small installation is just as efficient as the larger one.
4. Its wide crushing range. The stamp will take a 2-inch feed and reduce it efficiently, in one operation, to any size down to 16 mesh. The stamp duty, of course, is lower with the finer discharge.
5. Its ability to discharge a product that is very suitable for concentration on tables.

The present practice is to use coarser screens on the stamps and after a roughing treatment on tables, to re-grind in tube-mills or Hardinge mills loaded with iron balls. Details of practice are given later in the descriptions of various milling plants.

Tube-Mills for Fine Grinding

For fine grinding, the tube-mill is used in nearly every instance, though a few plants use the Hardinge mill for this purpose. In tube-milling the important factors are: the load circulating through the mill, the dilution of the pulp, the size of the balls, and the size and character of the feed. On these points details are given later in the descriptions of actual practice.

The present tendency is to substitute iron balls for flint pebbles in the tube-mills. These are used in sizes ranging from 1 inch to 4 inches, depending on the size of the feed to the mill. A mill loaded with iron balls shows a marked increase in tonnage over one using flint pebbles, provided each is loaded to the centre, volume for volume. The cost of grinding is about the same in each case, as the consumption of power increases in proportion to the tonnage ground. The saving effected is that the output is enlarged without increasing the number of machines. Crushing with iron balls has the additional advantage of enabling the tube-mill to take a coarser feed. At the Coniagas mill, material as coarse as ½ inch is now being ground in tube-mills using 4-inch iron balls. At this plant the substitution of iron balls for pebbles has made possible a large increase in daily capacity without installing additional equipment.

Economic Limit of Crushing

The economic limit of crushing depends on the subsequent treatment of the ore. It is that point where the least crushing will liberate the most values, in a readily recoverable form. For gravity concentration this limit is about 16 mesh, as at this point the easily liberated values are set free, permitting the discharge of a sand-tailing averaging three to four ounces of silver to the ton. The sliming of the ore must be avoided as far as possible, as when once slimed, a certain amount of the values will float away, and no amount of mechanical concentration will save them. It is now recognized that, in the early days of the camp, the general tendency was to over-grind the ore preparatory for gravity concentration, causing an undue loss of values in the slimes. In the milling of the higher grades of ore, this is a point of vital importance.

The following tables give screen analyses of the stamp discharge at the Coniagas, O'Brien, and Nipissing mills, the Coniagas using coarse screens and the O'Brien a finer (14-mesh) screen. These tables illustrate clearly the nature of the crushing done and show the distribution of the values in the various products.

Table III.—Screen Analysis of Stamp Discharge

Coniagas mill, February 27th, 1923: Opening in battery screen, $\frac{3}{8}$ by $\frac{5}{8}$ in. or 9.525 m.m. by 15.875 m.m.; assay of general sample, 10.0 oz. of silver per ton; dilution, 5.5:1; tons per stamp in 24 hours, 5.53.

Mesh	Per cent.	Assay value	Per cent. Ag. value
On 6	28.29	4.4	12.81
" 6–8	10.31	6.2	6.61
" 8–10	10.22	11.0	11.57
" 10–14	7.95	9.2	7.53
" 14–20	8.04	8.0	6.61
" 20–28	7.10	14.5	10.64
" 28–35	7.00	11.2	8.06
" 35–48	3.12	12.8	4.13
" 48–65	2.55	21.4	5.69
" 65–100	2.84	18.1	5.27
" 100–150	1.32	19.0	2.59
" 150–200	1.70	26.2	4.65
Minus 200	9.56	14.0	13.84

Table IV.—Screen Analysis of Stamp Discharge

Coniagas mill, April 15th, 1923: Opening in battery screen, $\frac{3}{4}$ by $\frac{1}{2}$ inch or 19.050 m.m. by 12.700 m.m.; assay of general head, 10.0 oz. of silver per ton; tons per stamp in 24 hours, 6.36.

Mesh	Per cent.	Assay value	Per cent. Ag. value
On 6	35.95	4.2	14.40
" 8	9.92	7.3	6.90
" 10	8.25	8.5	6.66
" 14	8.52	12.5	10.20
" 20	4.42	18.1	7.60
" 28	6.57	12.2	7.60
" 35	3.93	22.2	8.30
" 48	3.88	20.1	7.40
" 65	3.11	20.1	6.00
" 100	2.51	20.6	5.00
" 150	2.18	16.2	3.80
" 200	1.14	28.8	2.84
Minus 200	9.56	14.8	13.30

Table V.—Screen Analysis of Stamp Discharge

O'Brien mill, April 30, 1923: Opening of battery screen, 0.0212 by 0.2811 in., or 0.5386 m.m. by 7.276 m.m. (14 mesh); assay of general head, 14.6 oz. of silver per ton; tons per stamp in 24 hours, 2.78.

Mesh	Per cent.	Assay value	Per cent. Ag. value
On 14	3.00	4.4	0.9
" 20	9.34	5.0	3.3
" 28	11.10	11.2	8.8
" 35	10.18	18.1	13.1
" 48	9.34	17.3	11.6
" 65	7.96	14.6	8.3
" 100	8.96	14.8	9.5
" 150	6.89	15.8	7.8
" 200	5.75	19.0	7.8
Minus 200	27.49	14.7	28.9

TABLE VI.—SIZING ANALYSIS ON BATTERY DISCHARGE

Nipissing Mines: 40 – 1500 stamps; 8-inch drop, 100 drops per minute, using 4-mesh screens on batteries (16 holes to sq. in.) Dilution of pulp, 3.3:1.

Screen size	Battery discharge	Cumulative
	per cent.	per cent.
+ 4	0.0	......
– 4 + 6	3.822	......
– 6 + 8	5.755	9.577
– 8 + 10	6.307	15.884
– 10 + 14	4.696	20.580
– 14 + 20	4.696	25.276
– 20 + 28	4.604	29.880
– 28 + 35	4.374	34.254
– 35 + 48	4.696	38.950
– 48 + 65	3.729	42.679
– 65 + 100	5.202	47.881
– 100 + 150	3.039	50.920
– 150 + 200	6.492	57.412
– 200	13.444	70.856
Slime	29.144	100.000

For flotation, the economic limit of crushing is about an 80-mesh sand, though this will vary considerably with the character of the ore. Excessive sliming should be avoided, as the fine slimes give a poor recovery by this treatment.

The work done by flotation is shown in the screen analyses of the heads and tailings at the Coniagas and O'Brien mills, as given in the following tables. These analyses show the distribution of the values in the different sizes, and how the various sizes respond to the flotation treatment.

TABLE VII.—SCREEN ANALYSIS OF FLOTATION HEAD

Coniagas mill, February 27, 1923: Assay of general sample, 3.5 oz. of silver per ton.

Mesh	Per cent.	Assay value	Per cent. Ag. value
On 48	1.05	8.5	2.56
" 48–65	3.35	1.7	1.70
" 65–100	10.27	1.8	5.11
" 100–150	8.70	2.1	5.11
" 150–200	15.20	2.8	12.22
Minus 200	61.43	4.2	73.30

TABLE VII (*Continued*).—SCREEN ANALYSIS OF FLOTATION TAILINGS

General sample, 1.5. oz. of silver per ton.

Mesh	Per cent.	Assay value	Per cent. Ag. value
On 48	1.48	2.2	2.01
" 48–65	4.36	1.7	4.70
" 65–100	11.54	1.4	10.74
" 100–150	9.66	1.1	7.38
" 150–200	15.37	0.9	9.40
Minus 200	57.59	1.7	65.77

TABLE VIII.—SCREEN ANALYSIS OF FLOTATION HEAD

Coniagas mill, April 15, 1923: Assay of general head, 3.3 oz. of silver per ton.

Mesh	Per cent.	Assay value	Per cent. Ag. value
Plus 48	0.66	5.3	1.1
" 65	1.98	5.3	3.1
" 100	7.42	2.2	5.0
" 150	14.30	1.7	7.4
" 200	8.08	2.1	5.2
Minus 200	67.56	3.8	78.0

TABLE VIII (*Continued*).—SCREEN ANALYSIS OF FLOTATION TAIL

General tail, 1.3 oz. of silver per ton.

Mesh	Per cent.	Assay value	Per cent. Ag. value
Plus 48	1.33	1.7	1.5
" 65	3.74	1.7	4.6
" 100	11.12	1.2	10.0
" 150	13.35	0.8	8.4
" 200	10.14	0.8	6.1
Minus 200	60.32	1.5	69.2

TABLE IX.—SCREEN ANALYSIS OF FLOTATION HEAD

O'Brien mill, April 30th, 1923; general head 4.8 oz. of silver per ton.

Mesh	Per cent.	Assay value	Per cent. Ag. value
Plus 65	2.20	3.0	1.4
" 100	10.86	2.8	6.2
" 150	13.72	2.3	6.7
" 200	9.83	2.6	5.4
Minus 200	63.39	6.1	80.3

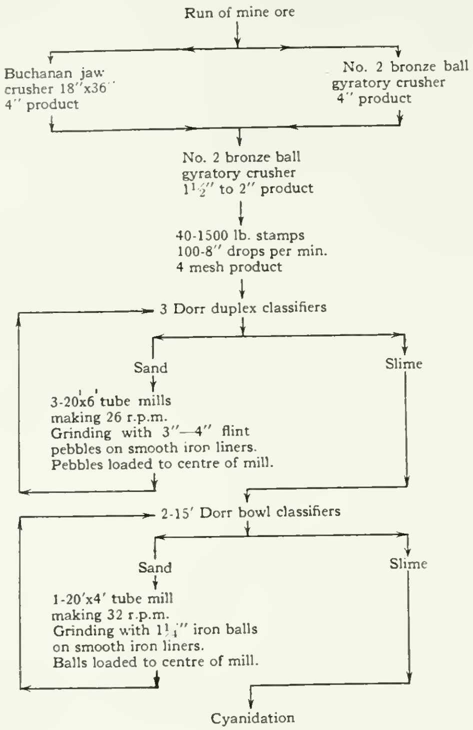
TABLE IX (*Continued*).—SCREEN ANALYSIS OF FLOTATION TAIL

General tail, 2.0 oz. of silver per ton.

Mesh	Per cent.	Assay value	Per cent. Ag. value
Plus 100	7.45	2.0	8.0
" 150	12.23	1.5	9.0
" 200	12.62	1.5	10.0
Minus 200	67.70	2.1	73.0

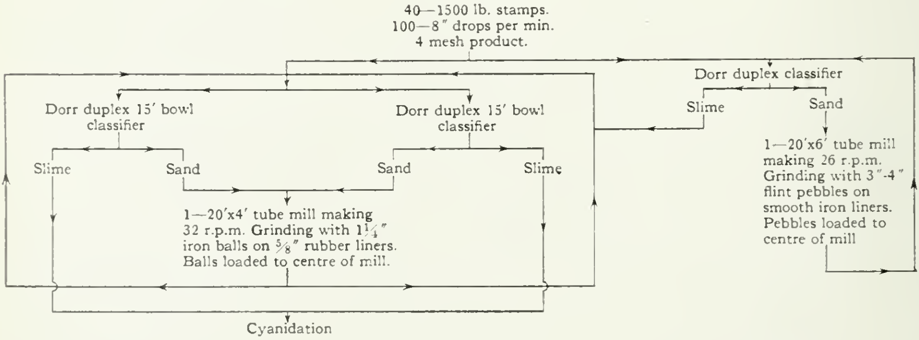
For cyanidation, owing to the refractory nature of the ore, excessively fine grinding is required to obtain dissolution of the values in a reasonable time of treatment. This is carried to the ultimate degree at the Nipissing low-grade mill, where the 200-mesh sands are ground to an impalpable slime with 1¼-inch iron balls, in tube-mills working in closed circuit with Dorr bowl classifiers.

TABLE X


Run of mine ore
Buchanan jaw crusher 18″x36″ 4″ product
No. 2 bronze ball gyratory crusher 4″ product
No. 2 bronze ball gyratory crusher 1½″ to 2″ product
40-1500 lb. stamps 100-8″ drops per min. 4 mesh product
3 Dorr duplex classifiers
Sand
Slime
3-20′x6′ tube mills making 26 r.p.m. Grinding with 3″—4″ flint pebbles on smooth iron liners. Pebbles loaded to centre of mill.
2-15′ Dorr bowl classifiers
Sand
Slime
1-20′x4′ tube mill making 32 r.p.m. Grinding with 1¼″ iron balls on smooth iron liners. Balls loaded to centre of mill.
Cyanidation

Nipissing Mining Company, Ltd.—Flow-sheet (1922) of preliminary crushing and fine grinding of the run-of-mine ore to −200 mesh product. The present practice (1923) with one tube-mill lined with rubber, is shown in table X*a*.

TABLE X*a*


40—1500 lb. stamps. 100—8″ drops per min. 4 mesh product.
Dorr duplex classifier
Slime
Sand
1—20′x6′ tube mill making 26 r.p.m. Grinding with 3″-4″ flint pebbles on smooth iron liners. Pebbles loaded to centre of mill
Dorr duplex 15′ bowl classifier
Slime
Sand
Dorr duplex 15′ bowl classifier
Sand
Slime
1—20′x4′ tube mill making 32 r.p.m. Grinding with 1¼″ iron balls on ⅝″ rubber liners. Balls loaded to centre of mill.
Cyanidation

The Cost of Crushing

Tables XI and XII give detailed costs of crushing at the Nipissing low-grade mill and the Cobalt Reduction Company's mill.

TABLE XI.—COST OF REDUCING RUN-OF-MINE ORE TO MINUS 200 MESH BY STAGES, NIPISSING MILL, YEARS 1913-1922, INCLUSIVE

Stages	Labour			Replacements and supplies		Power		Shops		Totals	
	Tons	Total cost	Cost per ton	Total cost	Cost per ton	Total cost	Cost per ton	Total cost	Cost per ton	Cost	Cost per ton
CRUSHING 1 18 by 36-inch jaw crusher at mine, and 2 No. 4 gyratory crushers, product reduced from run of mine to 1½ inches. .	$774,926	$91,811.41	$0.119	$40,314.61	$0.052	$20,523.10	$0.026	$13,851.66	$0.018	$166,500.78	$0.215
STAMPING 40 1500-lb. stamps, product reduced from 1½ inches to 4-mesh.	774,926	77 038.24	0.099	56,912.80	0.073	82,658.69	0.107	25,160.82	0.033	241,770.55	0.312
TUBE-MILLING Including classification; 3 20 by 6-ft. tube-mills grinding with flint pebbles. 1 20 by 4-ft. tube-mill re-grinding product from pebble-mills with 1¼-inch iron balls, product reduced from 4-mesh to minus 200-mesh fine slime.	774,926	101,876.16	0.132	171,551.00	0.222	251,851.12	0.325	38,415.68	0.048	563,693.96	0.727
Totals.	. . . . . .	$270,725.81	$0.350	$268,778.41	$0.347	$355,032.91	$0.458	$77,428.16	$0.099	$971,965.29	$1.254

Table XII gives the cost of crushing ore at the Cobalt Reduction works for a full year, namely, from June 1st, 1921, to May 31st, 1922:—

TABLE XII.—CRUSHING COSTS AT COBALT REDUCTION COMPANY MILL

Layout consisting of one No. 5 McCully crusher.
two No. 4 "K" Gates crushers.
one 6 ft. by 3 ft. by 1½-inch sizing trommel.
one 20 by 6-inch Blake type jaw crusher.
Ore reduction from 9 inches mine run to 1½ inches to stamps.

Tons crushed	97,050	
Hours run	3,600	
Tons per hour	26.958	cents
Operating cost per ton (labour)		3.692
Repair " " " (labour)		2.488
Repair " " " (material)		3.342
Power " " "		3.091
		12.613

COST OF STAMPING

Layout consisting of:—
75-1260 lb. stamps, 7½ inches drop, 104 drops per minute.
Screens—3-mesh double crimped steel wire gauge .078125 inch.
Running time, approximately 96 per cent.
Chrome steel shoes; hard iron dies.

Tons stamped	97,050	cents
Operating cost per ton (labour)		6.998
Repair " " " (labour)		3.588
Repair " " " (material)		12.089
Power " " "		10.904
		33.579

COST OF TUBE-MILLING, GRINDING TO 40 MESH

Product: plus 200-mesh, 45 per cent.; minus 200-mesh, 55 per cent.

Layout consisting of:—

One 5 by 20 tube-mill, 26 r.p.m. 60 H.P. Motor, 70.54 H.P.
Ball load, 18,000 lbs.
One 4 by 20 tube-mill, 29 r.p.m. 50 H.P. Motor, 70.90 H.P.
Ball load, 16,000 lbs.
One 5 by 16 tube-mill, 25 r.p.m. 50 H.P. Motor, 80.93 H.P.
Ball load, 16,000 lbs.
Liners, hard iron.
Balls, 2-inch hard iron.

Tons ground	97,050	cents
Operating cost per ton (labour)		2.332
Repair " " " (labour)		1.195
" " " (balls)		14.365
" " " (liners)		9.219
Power " " "		12.171
		39.282

Table XIII.—The Coniagas Mines, Limited, Consumption of Shoes and Dies per Ton of Ore Crushed—Years 1914-1922, Inclusive

Shoe.............230 lb. to 250 lb.
Die..............130 lb. to 143 lb.

Year	Tons stamped	Shoes		Lbs. per ton	Dies		Lbs. per ton	Total lbs. per ton	Battery screens	Manufacture, material, etc.
		No.	Weight		No.	Weight				
1914........	54,522	85	20,825	0.3819	95	13,395	0.2456	0.6275	16, 14, and 12 mesh	Shoe—Chrome steel Die — "
1915... ...	55,437	105	25,620	.4622	75	10,425	.1880	.7502	16, 14 mesh	Shoe— " Die — "
1916..... ..	56,973	105	25,305	.4414	85	11,815	.2073	.6514	"	Shoe— " Die — "
1917........	60,928	120	29,400	.4825	100	13,000	.2134	.6959	"	Shoe— " Die —Hard iron
1918.......	68,597	95	23,750	.3463	85	11,050	.1611	.5074	8, 6 mesh	Shoe—Chrome steel Die —Hard iron
1919........	71,743	105	24,775	.3453	95	12,350	.1721	.5174	4m.m. by ¾-in.	Shoe—Forged steel Die —Hard iron
1920...	97,634	160	36,800	.3699	135	19,305	.1941	.5640	3m.m. by ⅝-in.	Shoe—Chrome steel Die —Hard iron
1921......	113,279	135	33,750	.2866	120	17,160	.1457	.4323	2m.m. by ⅝-in and 2m.m. by 1-in.	Shoe—Chrome steel Die —Hard iron
1922.......	121,953	125	31,250	.2562	120	17,160	.1407	.3969	2m.m. by ⅜-in. and 2m.m. by 1-in.	Shoe—Chrome steel Die —Hard iron
Total.....	701,066	1,035	251,475	.....	910	125,660	.....	.....		
Average.....	....	...	......	0.3587	...	......	0.1792	0.5379		

TABLE XIV.—CONSUMPTION OF SHOES AND DIES PER TON OF ORE CRUSHED, NIPISSING MINING COMPANY, LIMITED, YEARS 1915-1922, INCLUSIVE.

Shoe.... 263 lbs.
Die..... 165 lbs.

Year	Tons stamped	Chrome shoes			Chrome dies			Replacement of stems and cam shafts		
		No.	Total weight	Lbs. per ton	No.	Total weight	Lbs. per ton	Swed. iron stems	Fag. iron C.S.	Stamp duty, tons per day per stamp
1915..........	77,183	130	34,190	0.4429	130	21,450	0.2779	0	1	6.57
1916..........	76,851	100	26,300	.3422	100	16,500	2147	3	0	6.70
1917..........	74,498	118	31,034	.4166	109	17,985	.2414	1	0	6.31
1918..........	80,274	95	24,985	.3112	83	13,695	.1706	1	3	6.98
1919..........	65,391	86	22,618	.3459	66	10,890	.1665	1	4	6.27
1920..........	81,700	101	26,563	.3251	91	15,015	.1838	0	0	6.36
1921..........	80,720	96	25,248	.3128	77	12,705	.1574	0	0	6.27
1922..........	82,025	85	22,355	.2725	56	9,240	.1126	0	0	7.05
Average.....	618,642	811	213,293	0.3448	712	117,480	0.1899	6	8	6.49

Stamp Battery Practice at Nipissing

Feeders are of the suspended Nelson type. Stamping is done in 0.12 per cent. cyanide solution, to pass a 4-mesh screen. There are forty stamps, each averaging 1,500 pounds, the weight of the various parts, when new, being as follows:—

	lbs.
Swedish iron stem 4 in. dia. by 16 ft. long.............	681
Cast steel tappet, 10-1-8 by 14 in. with gib and keys ...	190
Cast steel head, 9½ in dia. by 24 in. long.............	412
Forged chrome steel shoe, 9¼ in. by 12 in.............	254
	1,537

The stamps are arranged five to a battery. The order of drop is 1, 3, 5, 2, 4. Number of drops per minute is 100. Height of drop is eight inches. Height of discharge is one and a half inches. The cam shaft is of the Blanton fluted type, seven inches in diameter. The mortars are Fraser and Chalmers No. 161 type, for rapid discharge, and weigh, with steel liners, 12,410 pounds each. A rubber pad ¼-inch thick is placed between the mortar and the concrete mortar-block. A 40-horsepower motor is used to drive each battery of ten stamps. The stamp duty is from 6.01 to 7.05 tons every twenty-four hours.

The average daily stamp-duty at the Nipissing mill, over a period of ten years, is shown in the following table:—

TABLE XV.—STAMP DUTY, NIPISSING MILL

		Screen mesh per inch
1913—6.09	tons per stamp per day......	8 by 8 and 4 by 4
1914—6.01	" " " "	8 by 8 and 4 by 4
1915—6.57	" " " "	3 by 3 and 2 by 2
1916—6.70	" " " "	3 by 3 and 2 by 2
1917—6.20	" " " "	3 by 3 and 2 by 2
1918—6.98	" " " "	4 by 4
1919—6 27	" " " "	4 by 4
1920—6.36	" " " "	4 by 4
1921—6.26	" " " "	4 by 4
1922—7 05	" " " "	4 by 4

Rubber Liner for Tube-Mill

An experiment of more than ordinary interest is now in progress at the Nipissing mill. In the endeavour to reduce the cost and improve the grinding in tube-mills, the idea suggested itself, owing to its resiliency and wearing qualities, of using rubber as a liner, instead of hard iron or manganese steel.

Experimental grinding tests with rubber as a liner were carried out in 1921, in a 3-ft. by 18-inch tube-mill. After several months the results of these tests were so encouraging that it was decided to try the experiment on a commercial scale. A slab of rubber 3 ft. wide, 12 ft. 9 inches long, by 5/8 inches thick, was fitted in a 4-ft. by 20-ft. tube-mill, grinding a 4-mesh and finer product, and loaded with 1¼-inch iron balls. After three months of continuous operation the rubber was removed and weighed. The loss in weight was so small as to warrant the complete lining of a tube-mill.

In January, 1923, a 4-ft. by 20-ft. tube-mill was put into operation, loaded with 1¼-inch iron balls and lined with rubber throughout. To date (July 1st, 1923) the lining appears to be in good condition, and the tube-mill duty has been increased to a marked degree.

The experiment has proved conclusively that, as a grinding medium, the liner plays only a minor part. The chief function of the liner is to protect the shell of the mill.

The use of rubber as a lining may prove to be an important development in tube-mill practice. It is too early to predict just what it will mean to the industry.

TREATMENT OF LOW-GRADE ORE

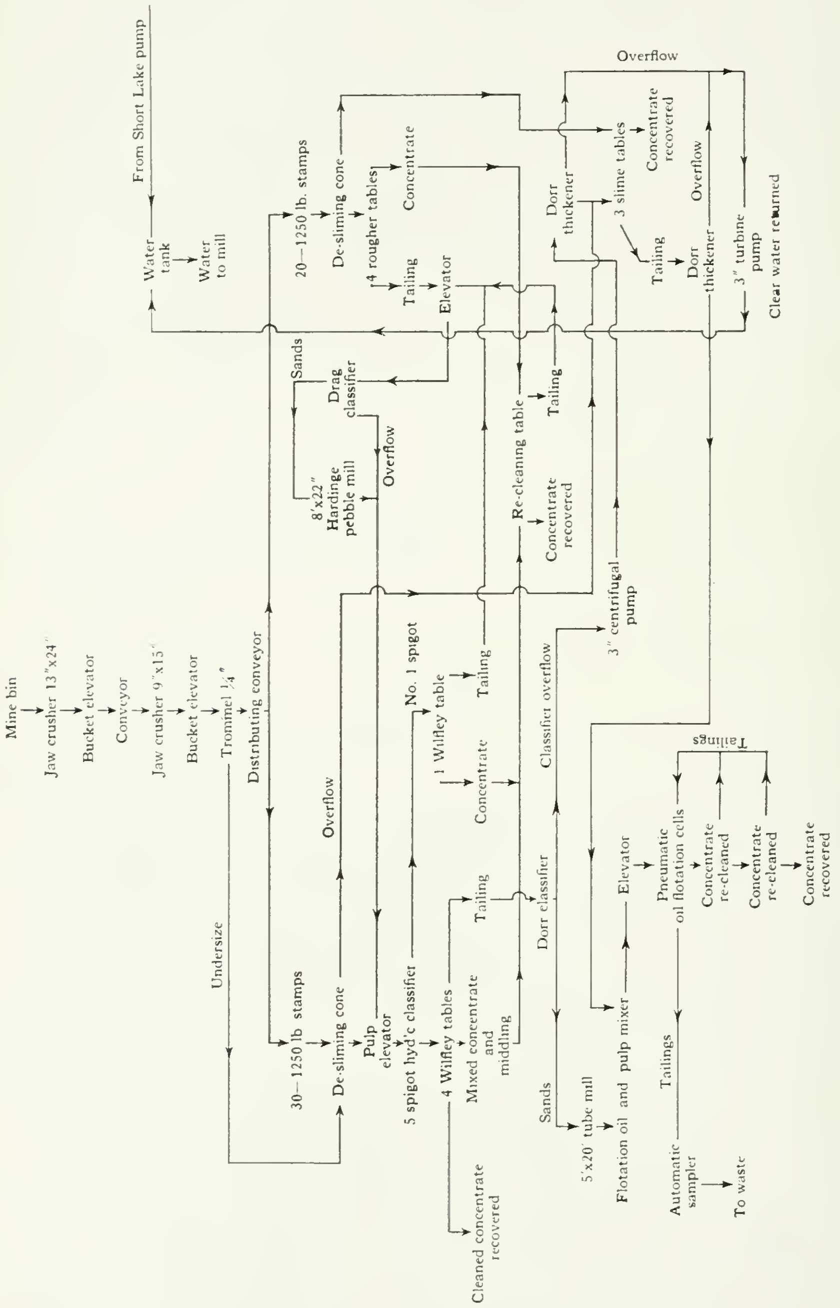
Introduction

Silver was first discovered at Cobalt in the fall of 1903, and as a result of the richness of the ore and the ease with which it was won, production started at once. Thus in 1904, a total of 158 tons of high-grade ore, containing 206,875 ounces of silver, was consigned to the smelters. For the first three years following discovery, only high-grade ore was sought, no attempt being made to extract the values from the low-grade material. Much of the ore was sacked underground, and the remainder hand-sorted in simple washing-plants.

In the summer of 1907, the McKinley-Darragh Mining Company erected and put into operation the first milling plant to treat the low-grade ore. This plant comprised a five-stamp battery, together with classifiers, a Wilfley table, and Frue vanners, and had a daily capacity of fifteen tons. Then followed the Buffalo and others in quick succession, until at one time or other a total of eighteen mills having a combined daily capacity of 2,100 tons, were engaged in recovering the values from the low-grade ore. At the time of writing (February, 1923) only five of these plants continue in operation.

The treatment of the low-grade ores by milling processes has been an important factor in increasing the production of silver from the district and prolonging the life of the camp. The high-grade ore is found in narrow cracks and veins that are extensive neither in length nor depth, and though exceedingly rich in silver, are soon worked out. This fact, together with the general failure to recognize the importance of the relatively large amount of low-grade milling ore, caused the prediction of a very short life for the Cobalt camp, which, in the early days, was variously placed at from three to seven years. The high-grade ore proved to be more extensive than was first anticipated, but even so, the transition

TABLE XV*a*



Mill flow-sheet, McKinley-Darragh-Savage Mines, February, 1923.

from a high-grade to a low-grade camp was rapid, and methods were soon sought for treating the accumulated reserves of low-grade ore. To-day the positions are completely reversed. In most of the mines, the high-grade ore is now only incidental, and the production of the camp depends very largely on the recovery of the values from the low-grade ore, by milling processes. This point is brought out clearly by the following table of silver production, taken from the Thirtieth Annual Report of the Department of Mines, which shows that about 50 per cent. of the total production has been in the form of concentrates, bullion, and residues from milling and metallurgical treatment. It will be noted too that there is no record of concentrates until the year 1908, the concentrates produced in 1907 being shipped and credited as high-grade ore.

TABLE XVI.—PRODUCTION, SILVER MINES, 1904 TO 1920

Year	No. of producing mines	Shipments and silver contents								
		Ore			Concentrates and residues			Bullion	Total	
		Tons	Oz.	Av. per ton. oz.	Tons	Oz.	Av. per ton. oz.	Oz.	Oz.	Value
1904..	4	158	206,875	1,309	....	....	......	....	206,875	$111,887
1905..	16	2,144	2,451,356	1,143	....	....	......	....	2,451,356	1,360,503
1906..	17	5,335	5,401,766	1,013	....	....	......	....	5,401,766	3,667,551
1907..	28	14,788	10,023,311	677	....	....	......	....	10,023,311	6,155,391
1908..	30	24,487	18,022,480	736	1,137	1,415,395	1,244	....	19,437,875	9,133,378
1909..	31	27,729	22,436,355	809	2,948	3,461,470	1,174	....	25,897,825	12,461,576
1910..	41	27,437	22,581,714	821	6,845	7,082,834	1,030	980,633	30,645,181	15,478,047
1911..	34	17,278	20,318,626	1,176	9,375	8,056,189	858	3,132,976	31,507,791	15,953,847
1912..	30	10,719	15,395,504	1,436	11,214	9,768,228	871	5,080,127	30,243,859	17,408,935
1913..	35	9,861	13,668,079	1,386	11,016	8,489,321	770	7,524,575	29,681,975	16,553,981
1914..	32	4,302	6,504,753	1,511	12,152	8,915,958	733	9,742,130	25,162,841	12,765,461
1915..	24	2,865	6,758,286	2,359	11,996	10,001,548	834	7,986,700	24,746,534	12,135,816
1916..	28	2,177	4,672,500	2,146	8,561	7,598,011	887	7,644,579	19,915,090	12,643,175
1917..	28	2,288	3,271,353	1,429	13,720	6,445,243	469	8,053,318	19,401,893	16,121,013
1918..	38	1,456	1,401,050	962	17,958	5,793,756	323	10,466,888	17,661,694	17,341,790
1919..	33	850	806,341	949	15,208	4,024,212	265	6,383,764	11,214,317	12,738,994
1920..	35	578	668,081	1,152	9,757	3,777,812	387	6,402,423	10,846,321	10,654,471
Total..	....	154,452	154,586,430	1,001	131,187	84,839,977	643	73,398,113	314,446,504	$192,685,816

The recovery of the values from the low-grade mill rock has been effected by three distinct processes—gravity concentration, cyanidation, and flotation. Of these, the older treatments of gravity concentration and cyanidation have been of outstanding importance, and to them must be credited, largely, the silver values won by milling operations. The flotation process is, in comparison, a recent innovation, although it plays a useful part in the recovery of values from the slimes and low-grade sands. These processes will now be discussed in some detail.

Gravity Concentration

Preliminary Treatment

Early Practice.—Early operations were confined to the recovery of high-grade ore, which was sorted from the rock as broken in the mine. Later, sorting-plants were introduced, and the run-of-mine ore passed over bumping tables. During this period, the following products were obtained and shipped to the smelters:—

1. A high-grade ore carrying from 1,000 to 4,000 ounces of silver to the ton.
2. A lower grade ore, averaging about 400 ounces.
3. A screening or grizzly-product, averaging 125 ounces.

Later Practice.—With the introduction of gravity concentration plants in 1907, the general practice was to give the ore a preliminary washing treatment before sending it on for finer crushing, with subsequent treatment on tables. The ore was crushed in breakers, and sized on screens or in trommels; the oversize from the trommel was then hand-sorted on picking belts, while the finer sizes were concentrated on Hartz or Richards jigs. The rejects from this treatment, after being de-watered, were sent to the stamp bins.

The purpose of the preliminary washing treatment was to recover portions of the high-grade vein-matter broken into the mill-rock. The product was a clean high-grade ore, and represented about 50 per cent. of the total values recovered by the milling operations. It was desirable to recover this material without subjecting it to finer crushing, owing to the tendency of the high-grade ore to slime, with a consequent loss of some of the values.

Present Practice.—As a result of changing conditions, the tendency of later years has been to abandon the preliminary treatment, and at the present time there are no washing plants in operation. Later improvements in practice, and the lowering of the grade of the ore, are contributing causes leading to this change. With the impoverishment of the ore and the necessity of milling a constantly decreasing grade of wall-rock, the cost of recovering the small amount of high-grade vein-matter by a sorting and jigging treatment became unduly high. The elimination of the preliminary treatment was assisted, also, by various improvements in practice, of which the most outstanding was the development of the flotation process for the recovery of values from the slimes. It was found that gravity concentration, followed by a re-treatment of the slimes either by flotation or cyanidation, would effect a satisfactory recovery of the small amount of high-grade present in the ore. Similar satisfactory results were obtained in cyanidation by recovering much of the high-grade as a coarse concentrate by gravity concentration, prior to fine grinding for cyanide treatment. Thus, at the Nipissing low-grade mill, table concentration below the stamps has made unnecessary the more expensive preliminary washing-treatment above the stamps. In addition to a lower treatment cost, these changes have shown a marked improvement in practice. The elimination of the washing-plant has simplified the flow-sheet of the ore-treatment processes, a thing much to be desired. Table concentration removes the high-grade silver values more completely than did the former sorting practice, and so takes care of all fluctuations in the value of the feed to the mill. The grade of the ore, after concentration on tables, is thus more or less standardized, and this helps to stabilize the subsequent treatment by flotation or cyanidation.

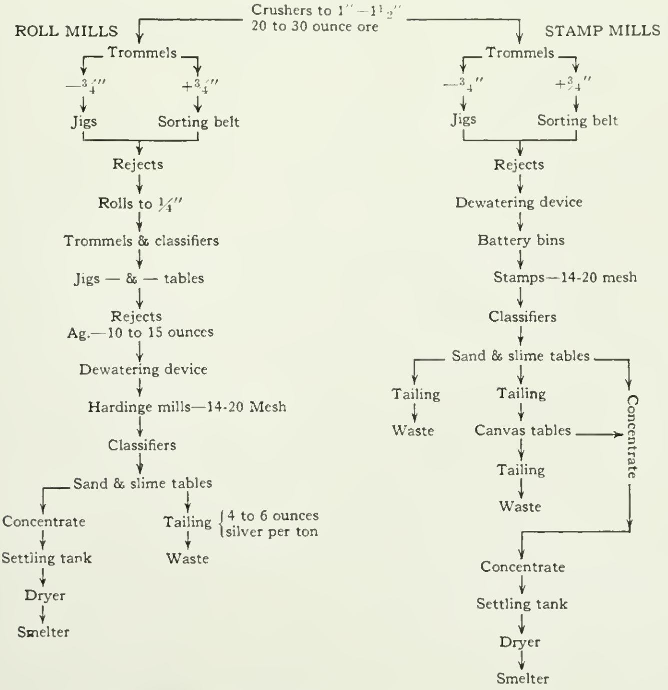
Treatment Below the Stamps

General.—Following finer crushing to liberate the values in the wall-rock and low-grade vein-matter, the treatment of the ore by gravity concentration shows a considerable variation in the methods used to recover the values. For this purpose all the standard machines and devices known—reciprocating tables, both sand and slime tables, vanners, buddles, and canvas tables—have been tried out at some time or other. Of all these, the reciprocating table has been used most widely from the beginning of operations down to the present time. The tables used include all the standard machines on the market—Wilfley, James, Deister, and Overstrom tables for the sands, and James and Deister tables for the slimes. All of these have given satisfactory results, at a low cost.

Concentration on tables is effective on sizes ranging from ½-inch to 200 mesh and finer. The ratio of concentration is very high, being as much as 125 to 1. The sand tables recover a high-grade concentrate, containing from 500 to 4,000 ounces of silver to the ton and discharge a low-grade tailing assaying from 2.5 to 4 ounces of silver to the ton. The slimes are concentrated less readily. Working on a feed assaying 15 ounces of silver to the ton, the slime tables make a concentrate containing 400 to 3,000 ounces of silver, and discharge a tailing assaying 7 ounces of silver to the ton. The recovery effected will depend on the character of the ore and the skill of the operator. The re-treatment of this slime tailing on canvas tables will recover another ounce of silver as a low-grade concentrate assaying from 125 to 200 ounces of silver to the ton.

Early Practice.—The early practice was to crush rather fine through 20, 30, 40 mesh, and classify closely into sand and slime. Crushing was effected in stamps, Chilean mills, Huntingdon mills, Ball mills, and Hardinge mills. The sand was treated on James, Wilfley, Deister, and Overstrom tables, making a low-grade sand tailing which went to waste, and a clean high-grade concentrate which was dried and shipped to the smelter. The middling, either with or without re-grinding, was retreated on middling tables, making a concentrate and a tailing which was discharged with the general sand tailing. The overflow from the classifier, after thickening in Callow cones or Dorr thickeners, was treated on slime tables or vanners, and the tailings, after re-treatment on canvas tables, were either impounded or sent to waste. The concentrates from the slime tables and canvas tables were dried and shipped. With certain modifications, this continued to be the general practice in gravity concentration until the introduction of the flotation process in 1916. This is shown in skeleton outline in the following flow-sheet:—

TABLE XVII

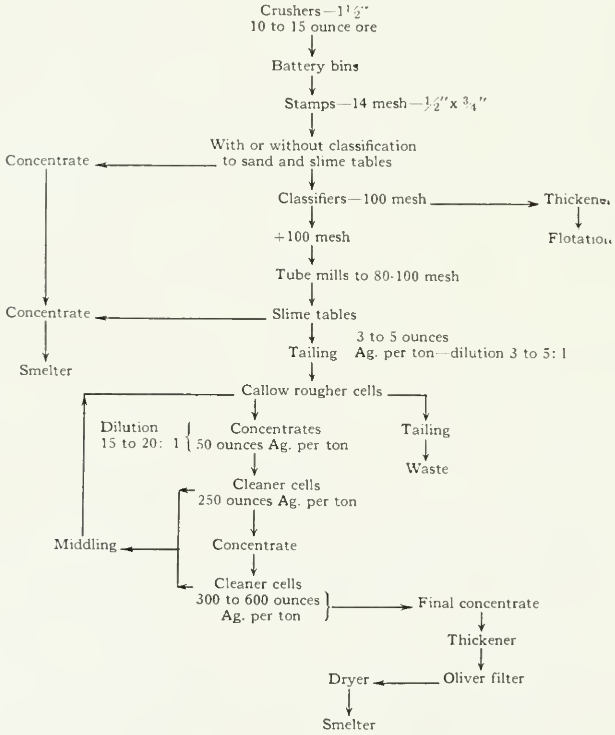


Flow-sheet of early practice in gravity concentration to 1916.

Present Practice.—The present practice in gravity concentration dates from the introduction of the flotation process in 1916, when the improvement in the treatment of slimes, together with the higher price of silver and the falling off in the general grade of the ore, made certain changes in operation necessary and desirable. The preliminary sorting and jigging treatment was discontinued, and the stamp duty increased by the use of coarser battery-screens. The older practice was still followed, of recovering as much of the values as economically possible by gravity concentration on sand and slime tables, the tailing from the slime tables going direct to the flotation plant. The sand tailing, which formerly was sent to waste, was now re-ground and sent to the flotation machines. The re-grinding of the sands was done in tube-mills, using a silex lining and flint pebbles. Later developments resulted in substituting iron balls for the pebbles.

The resulting practice now in general use is shown in skeleton outline in the following flow-sheet:—

TABLE XVIII

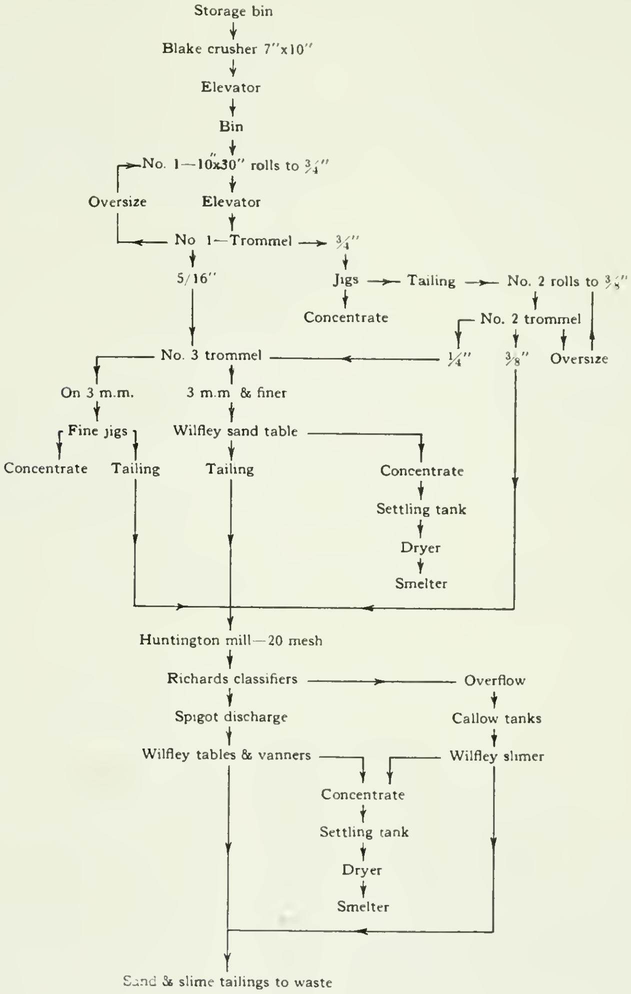


Flow-sheet showing general practice in gravity concentration and flotation.

Outline of Coniagas Practice

The various changes made in concentration, as applied to the ores of Cobalt, and the development of the art to meet changing conditions, are well illustrated in the following outline of the practice of the Coniagas concentrator. This plant was started on September 24th, 1907, and was the second mill to begin operating in Cobalt. It had a daily capacity of sixty tons. The original flow-sheet was as follows:—

TABLE XIX



Coniagas mill, original flow-sheet.

Early Practice.—Much trouble was experienced in the crushing section of this plant, and it was soon discovered that the equipment was too light for the work. The rock was found to be very hard and tough, causing a heavy breakage of crusher parts, and excessive wear and tear on the rolls and Huntingdon mill. A Krupp ball mill was tried out, but the results were not satisfactory. A test was then made with stamps, using the 5-stamp mill of the McKinley-Darragh. As a result of these tests the Coniagas plant was remodelled and thirty stamps were installed in 1908. These were later increased by an additional thirty stamps. With sixty stamps crushing to 16-mesh, the mill had a daily capacity of 180 tons.

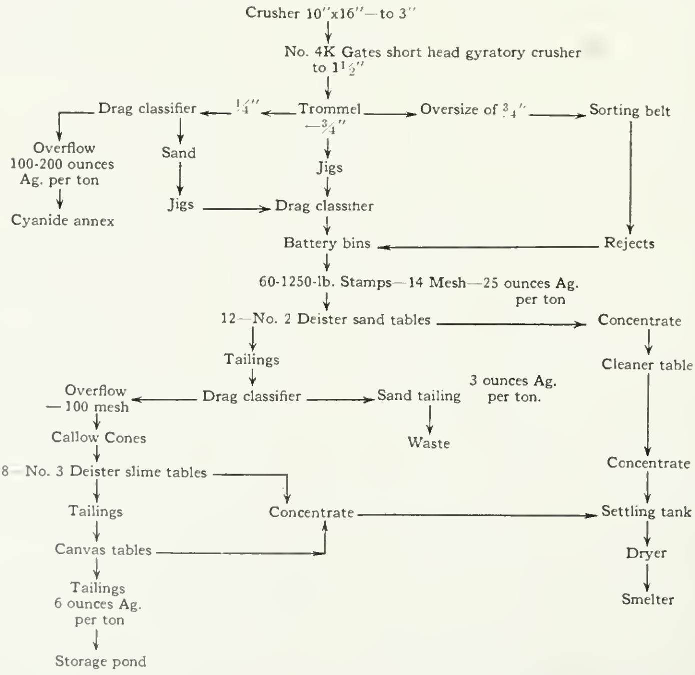
For some time a system of straight gravity concentration was used. The ore, after crushing, was given a preliminary sorting and jigging treatment, the rejects being sent to the battery bins. The battery discharge was concentrated on Deister sand and slime tables, and the tailing from the slime tables was re-treated on canvas tables. The sands were sent to waste, and the slime tailing was impounded.

A point of some interest was the use in this plant of a pilot-table to check the work of the concentrating tables. A continuous sample, cut from the tailing going to waste, was fed over a regular No. 2 Deister table, and the feed and the tailing from this table were assayed daily. The use of this pilot-table had also a good moral effect on the operators, since the amount of free mineral on the same afforded a continuous record of the efficiency of the work being done by the other tables in the mill.

Later Practice.—Later, when a number of oxidized veins were developed, trouble was experienced in handling the primary slime from the mine. This amounted to about five tons a day with a silver content of from 100 to 150 ounces to the ton. The experiment was tried of isolating this material, and treating it in a separate concentrating circuit, but this was unsuccessful, as the final tailing from this treatment carried approximately seventy-five ounces of silver to the ton. To handle these primary slimes, a small temporary cyanide annex was installed at a low cost. This plant continued in operation for several years until the oxidized veins were worked out, and the grade of the primary slimes fell to a point where they could no longer be treated at a profit by the cyanide process.

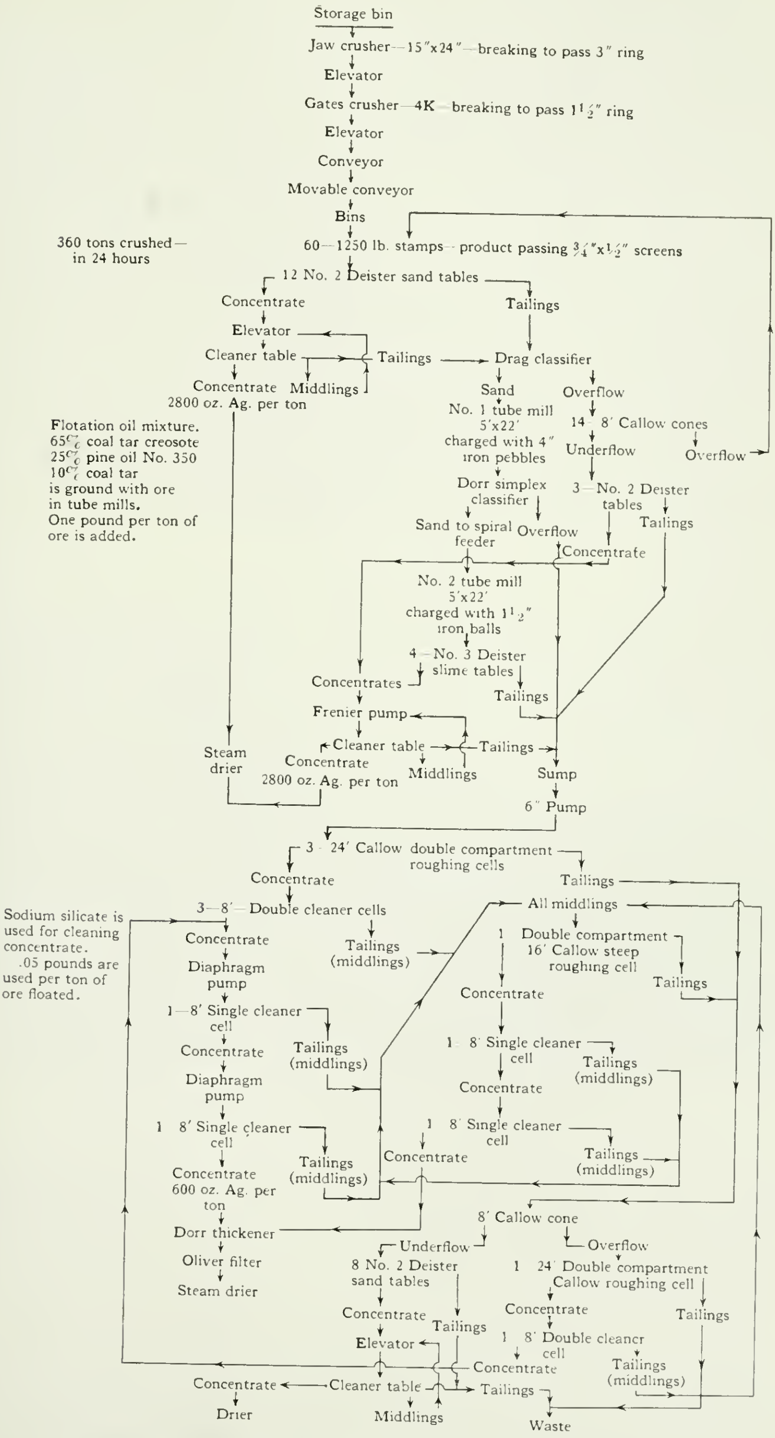
A general flow-sheet of the mill at the time the Callow flotation plant was put into operation (February 6th, 1917) was as follows:—

TABLE XX



Coniagas mill, flow-sheet, 1916, before adopting flotation.

TABLE XX*a*



360 tons crushed—
in 24 hours

Flotation oil mixture.
65% coal tar creosote
25% pine oil No. 350
10% coal tar
is ground with ore
in tube mills.
One pound per ton of
ore is added.

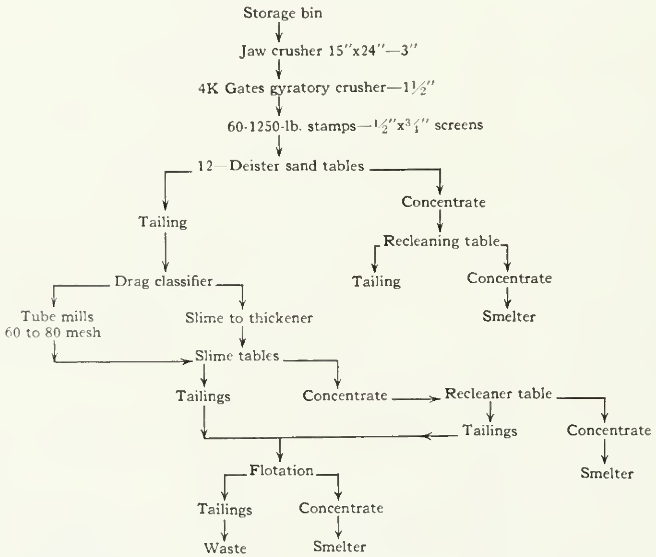
Sodium silicate is
used for cleaning
concentrate.
.05 pounds are
used per ton of
ore floated.

Coniagas Mines, Limited, flow-sheet of concentration and flotation plants.

Present Practice.—When the flotation process was first introduced in the Coniagas mill in 1917, the only change made in the flow-sheet was to eliminate the canvas tables and to send the tailing from the slime tables direct to the flotation machines. This resulted in a final slime tailing of approximately 1.5 ounces of silver to the ton. Early in 1918 two tube-mills, five feet by twenty-two feet, lined with silex and using Danish pebbles, were installed to re-grind the sand tailings to 80 mesh for further treatment by flotation. At the same time, in order to increase the stamp-duty, the battery-screens were changed from 16 mesh to 10 mesh. With the lowering of the grade of ore, it became imperative to treat an increased tonnage of low-grade rock, and maintain a high recovery, with a low working cost. The preliminary sorting and jigging treatment was now discontinued, the increased efficiency of the milling process being relied on to recover any small amount of high grade present in the ore. By using battery screens ½ inch by ¾ inch, and substituting iron balls for pebbles in the tube-mills, the capacity of the mill was raised to 350 tons a day. The battery-discharge is given a roughing treatment on sand tables, making a low-grade concentrate which is re-cleaned, the coarse tailing going to the ball tube-mills. The ball-tube-mill discharge, after classification, together with the battery slimes is treated on slime tables, and the slime tailing sent to the flotation machines.

This process is given in outline in the following flow-sheet:—

Table XXI



Coniagas mill, present practice. For graphic details, see Coniagas Mines, Ltd., flow-sheet of concentration and flotation plants, page 271.

Additional Notes on Gravity Concentration

Screening Out Mine Fines.—For a time it was the practice in one mill to screen out the original mine fines, which were shipped direct to the smelter. This was later discontinued, as it was found more profitable to treat this product on tables, eliminating the low-grade rock, and producing a clean concentrate.

Skimming on the Jigs.—Owing to the small amount of valuable mineral present in the ore, it was found impossible to use a continuous discharge on the jigs. Accordingly the practice was to allow the concentrates to accumulate on the screens, and remove them periodically by skimming.

Classification of Table Feed.—The relative advantage of a close classification of the feed to the tables has been a disputed question in the Cobalt camp. In the Coniagas mill, classification before treatment on sand tables was dispensed with. The battery discharge was sent direct to the tables, the tailing being then classified into sand and slime by means of a drag classifier. The sands were sent to waste, and the slimes received a further treatment on slime and canvas tables. By this treatment it was shown that the sand tailing from an unclassified feed was as low in silver as from a closely classified one, and further, that 20 per cent. of the values in the concentrate produced by the sand tables was contained in the 200 mesh and finer sizes. In other words, on passing over the sand tables, the slime in the battery discharge was reduced 40 per cent. in silver content before receiving the final treatment on slime and canvas tables. These results are possible owing to the high specific gravity of the valuable minerals, and the ease with which they are recovered on tables. The removal, on the sand tables, of the more readily recovered values in the slime permitted of a closer adjustment in the subsequent treatment on slime tables.

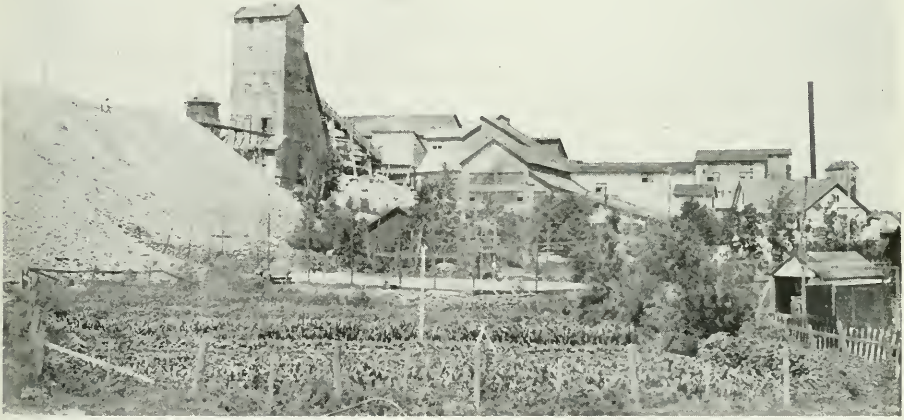


Fig. 62—Shaft and mill of the Coniagas Mines, Limited.

Re-cleaning Concentrates.—At most of the mills, it is the practice to make a clean tailing on the sand tables by cutting out a low-grade concentrate, which will include the free mineral, together with the true middling, and some low-grade rock. This low-grade concentrate contains about 500 ounces of silver to the ton. It is brought up to the required grade by re-treatment on cleaning-tables. This treatment produces the following products:—

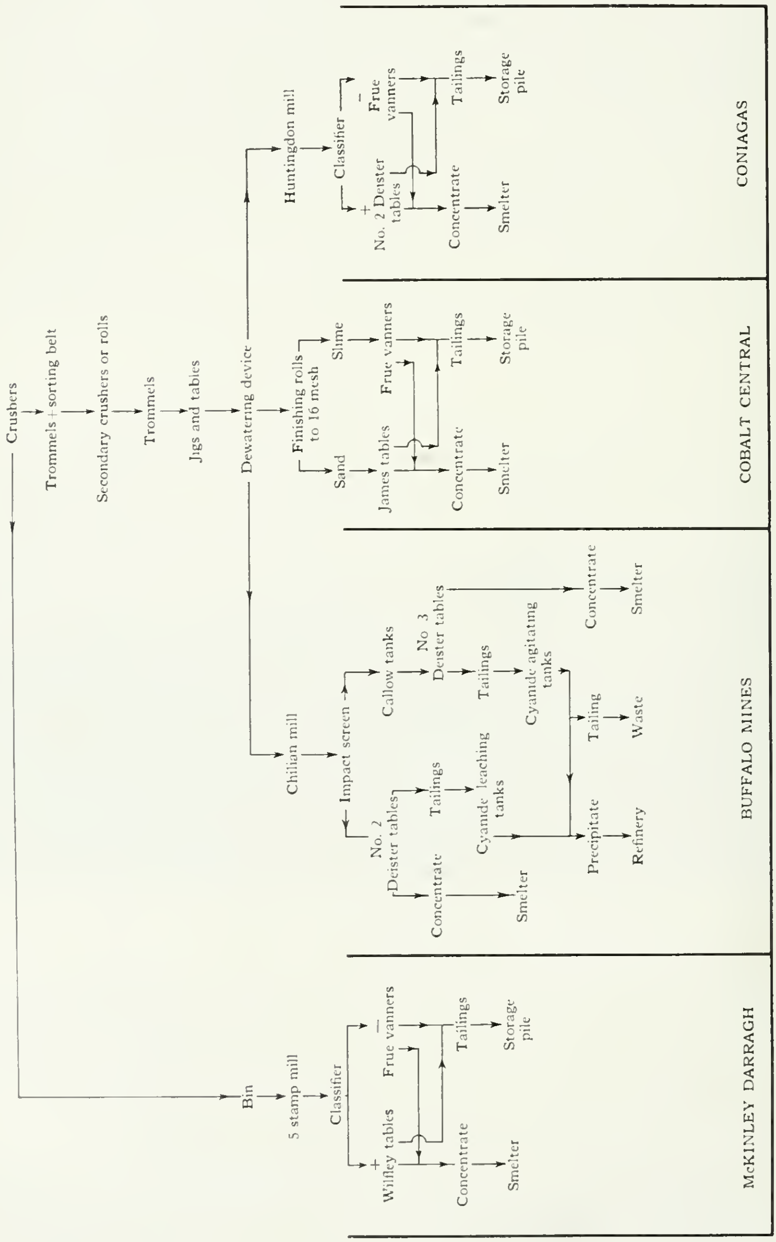
(a) A clean high-grade concentrate, containing from 1,500 to 3,000 ounces of silver to the ton.

(b) A high-grade middling, which is returned to the cleaning-table in closed circuit, without re-grinding.

(c) A low-grade tailing, which is sent to the tube-mills for grinding and further treatment.

The following flow-sheets indicate the milling practice in operation at several of the leading mines and mills. Comparative sheets are given for the years 1907, 1914, 1917, and 1923, the last three mentioned appearing as inserts facing pages 274, 276, and 278, respectively.

TABLE XXI*a*



Comparative flow-sheet, Cobalt milling practice, 1907.

The advantages of this practice are developed in the following section.

The Treatment of Middling.—A disputed question, in the treatment of ores by gravity concentration, is the disposal to be made of the inevitable middling product, as to whether or not this should be re-ground, before receiving further treatment. Both systems have been practiced in the treatment of Cobalt ores. As indicated in the preceding section, at several mills the re-grinding of the middling is not favoured, and this product is returned in closed circuit on the table used to re-clean the concentrates. From the following considerations, it is claimed that this practice will yield a higher recovery of the silver values in the ore.

In treating Cobalt ores by gravity concentration, the ratio of concentration is so high that the concentrate discharged forms only a narrow ribbon or streak on the table. The order of stratification is interesting; with minerals of the same degree of fineness, the niccolite has a tendency to ride ahead, followed in turn by fine silver, cobalt minerals. pyrite and chalcopyrite. Coarser particles of mineral on the other hand tend to come off with the middling. Owing to the narrow zone of mineral on the table, it is impossible to take off a clean concentrate without cutting a considerable amount of free mineral into the middling.

The middling thus includes both free mineral, and coarser particles of rock, together with the true middling, some of which is high in grade. The objection to re-grinding this product is the inevitable loss of silver resulting from the sliming of the free mineral present. This loss is avoided in the practice already outlined, of cutting out a low-grade concentrate, which will include the free mineral, true middling, and rock, and re-cleaning this product on a separate table. By returning the high-grade middling product to this re-treatment table without re-grinding, a zone of true middling is built up, which forms a line of demarcation between the free high-grade mineral on the one hand, and the low-grade rock on the other. This makes it possible to recover a high-grade concentrate for shipment and to eliminate a low-grade tailing, which is sent to the tube-mills for re-grinding and further treatment. The true middling continues to accumulate in the circuit until it escapes by one or another of these paths, the higher grade finally cutting into the concentrate, and the lower-grade material passing into the tailing.

Minor Developments.—Various minor developments may here be noted briefly. All varieties and combinations of riffles have been tried out, as well as tables without riffles. To replace the standard linoleum deck, various materials have been tried, including tops made of iron, monel metal, and glass. Working on unsized material, none of these were a success, as, on account of the nature of the material and the smoothness of the top, they failed to make a clean separation of ore and gangue.

Of some interest is the canvas-covered deck, used at the Nipissing low-grade mill, for concentrating in cyanide solution. The surface is of ten ounce canvas, laid on wet P. & B. paint on a wood deck. This is given two coats of P. &. B. paint, before tacking on the riffles. This deck costs $28.00 to renew and will last for one year. It handles satisfactorily a feed of 4 mesh and finer, in a solution containing 0.2 per cent. KCN and 0.25 per cent. protective alkali.

TABLE XXII.—PRODUCTION CHART OF CONIAGAS MILL FROM 1908 TO 1921

Year	Tonnage milled	Assay of heads	Assay of tailing	Ounces to waste	Low-grade concentrates recovered, tons	High-grade concentrates recovered, tons	Total concentrates recovered, tons	Silver recovered, ounces	Cost per oz. milled on oz. recovered	Smelting refining per oz. recovered	Total cost per oz. on oz. recovered
1908 (*a*).....	14,064	34.5	6.1	122,915	....	....	297.0	400,800	$0.0753	....	....
1909 (*b*).....	19,038	37.0	5.5	107,089	....	....	426.0	599,975	.0652	....	....
1910 (*c*).....	33,539	33.6	5.3	182,140	....	....	645.5	949,901	.0427	....	....
1911 (*d*).....	52,320	36.3	4.75	241,658	466.8	951.6	1418.4	1,643,616	.0351	....	....
1912........	53,627	34.1	5.05	265,521	484.2	803.3	1287.5	1,564,164	0309	$0 0444	$0.0753
1913........	54,890	28.3	4.23	228,020	423.3	611.0	1034.3	1,323,004	.0385	.0432	.0817
1914........	54,522	24.0	4.21	226,354	251.8	496.4	748.2	1,045,872	.0515	.0358	.0873
1915........	55,437	23.0	3.94	208,262	155.8	473.9	629.7	1,061,621	.0492	.0325	.0817
1916 (*e*).....	56,973	25.7	3.99	226,119	152.4	495.5	647.9	1,250,378	.0498	.0427	.0925
1917 (*f*).....	60,928	18.5	2.98	178,303	260.4	482.0	742.4	952,303	.0874	.0431	.1305
1918 (*g*).....	68,597	15.9	1.75	119,305	866.8	529.5	1396.3	828,621	.1457	.0798	.2255
1919........	71,713	13.1	1.38	96,567	630.5	322.8	953.3	898,150	.1410	.0745	.2155
1920........	97,634	10.2	1.43	135,488	522.8	388.6	911.4	974,670	.2397	.0735	.3132
1921........	113,279	11.3	1.62	181,499	536.9	402.4	939.3	1,186,971	.1793	.0633	.2426
Totals.......	806,591	....	....	2,519,240	4,751.7	5,957.0	12,077.2	14,680,046	....	....	....
Averages....	57,614	21.17	3.12	179,946	432.0	541.5	862.6	1,048,575	$0.1503	$0.0400	$0.1903

(*a*) Crusher rolls—Krupp & Huntington mills—changing to stamps.
(*b*) Thirty stamps to 20-mesh.
(*c*) Sixty stamps to 16-mesh.
(*d*) Canvas table plant put into operation January 1st, 1911.
(*e*) Cyanidation of primary slime from mine started February 26th, 1916.
(*f*) Callow flotation plant put into operation February 6th, 1917.
(*g*) Cyanide plant closed down November 20th, 1918—tube mills grinding all sand tailings.

Cyanidation

The early attempts to cyanide the Cobalt ores were not very successful, with the result that the first milling plants built to recover the silver values from the low-grade ores made use of the simpler process of gravity concentration. The ores of Cobalt are very complex and refractory, and their treatment by cyanidation presented a number of difficulties. Early experiments showed that the loss in the tailing was high, and the consumption of cyanide was heavy; that the working solution rapidly became foul, and lost its dissolving efficiency; and that the extraction of the silver was unsatisfactory, unless the time of treatment was unduly prolonged. These points have already been treated in some detail in the discussion on the nature of the ore. The solution of these difficulties, as a result of later research, has led to some important improvements in the treatment of complex silver ores by cyanidation. These include the development of aluminium precipitation, and the desulphurization process. Later, when it became necessary to resort to precipitation by sodium sulphide, suitable processes were developed to reduce the resulting silver sulphide to metallic silver, thus removing the chief objection to this method of precipitation. The result of these developments was to place cyanidation on an equal basis, as a competitive process, with the older treatment by gravity concentration.

Early Practice

Buffalo Mine.—Cyanidation was first used in Cobalt in 1908 in the mill at the Buffalo mine, as an accessory treatment to recover the high losses in the slime tailing. Here the ore was crushed in rolls and a Chilean mill, and separated into sands and fines on an impact screen. The sands were sent over tables, the tailing going to waste, and the slimes, after treatment on slime tables, went to the cyanide annex. The attempt was also made at the Buffalo mill to recover the values in the low-grade sand-tailing by cyanide leaching, but the experiment was not a success, and further work along this line was abandoned. Cyanidation was used also at the Nova Scotia mill (later the Dominion Reduction) in conjunction, at first, with amalgamation, and later with gravity concentration.

The O'Brien management did much of the pioneer work in developing a successful cyaniding practice, and in 1909 put into operation the first plant to treat the ore by cyanidation. In the O'Brien practice, the ore was given the usual preliminary treatment by hand-sorting and jigging, followed by a combined gravity-concentration and cyanidation treatment below the stamps. Aluminium precipitation was developed by the O'Brien metallurgists and was here used for the first time.

O'Brien Mine.—At the O'Brien, the ore was brought to the mill by a surface tram, using electric haulage, and weighed on a Fairbanks scale. It was then hand-sorted while being fed to a No. 5 Gates gyratory breaker, crushing to one and a half inches. The crushed ore was then separated into four sizes by a trommel, the coarser sizes treated on Hartz and Richards jigs, and the fines net to the stamp bins, together with the tailing from the jigs. The hand-sorted ore and jig concentrates were shipped to the smelter at Deloro. About 20 per cent. of the total mill recovery of silver was made by the preliminary treatment, most of it on the Hartz bull-jig.

Crushing in the stamps was in a two and a half pound cyanide solution, to pass a screen with 3-mesh opening. After some earlier modifications, the practice below the stamps was as follows: The pulp was sent to a Dorr classifier, working in closed circuit with the Hardinge mills and Deister tables; about

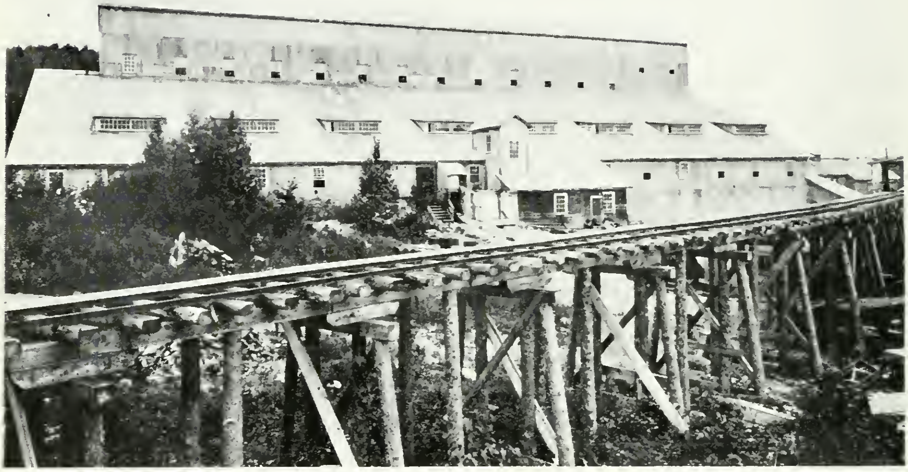


Fig. 63—O'Brien concentrator, Cobalt.

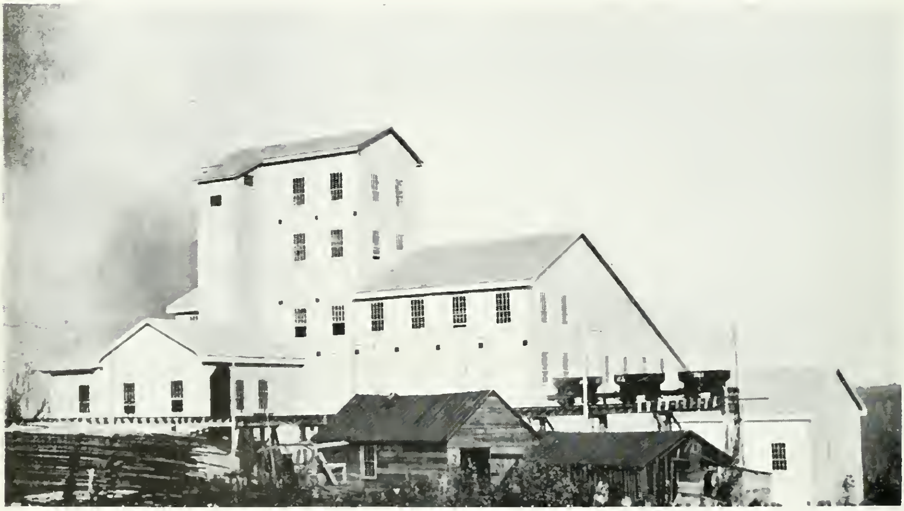


Fig. 64—O'Brien mill, destroyed by fire, September 4, 1922.

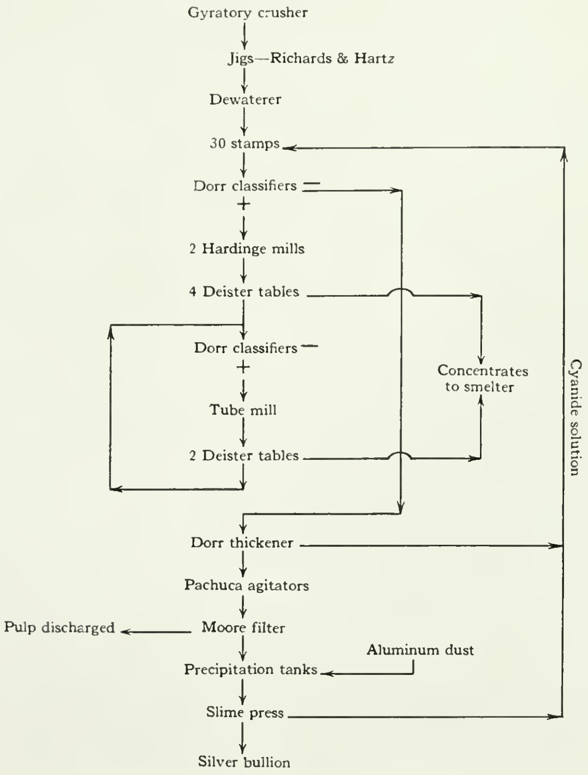
70 per cent. of the pulp, in the form of a sand, was re-ground in two Hardinge mills, and concentrated on three Deister tables, the tailing being returned to the Dorr classifier; the concentrate from the tables was shipped to the company smelter at Deloro. The table concentrate accounted for about 40 per cent. of the total recovery.

The overflow from the Dorr classifier, of which about 80 per cent. is 200 mesh and finer, passed to a 30-foot Dorr settler, and the thickened pulp was pumped to Pachuca tanks. Here the pulp was agitated for forty-eight hours in a cyanide solution made up to five pounds KCN to the ton. It was then filtered in a two-basket 24-leaf Moore filter, and the pregnant solution after clarifying was sent to the precipitating tank.

The silver was precipitated by means of aluminium dust, and the precipitate melted down without flux in a Harvey furnace, yielding a bullion about 960 fine. Later developments made it necessary to omit the preliminary jigging treatment, to modify the crushing practice, and to use precipitation by sodium sulphide. These developments are shown in the flow-sheet of O'Brien practice (see insert facing page 276).

The earlier practice, as used at the O'Brien, is shown in skeleton outline in the following table:

Table XXIII



Early practice at O'Brien mill.

Nipissing Mine.—Cyanidation, as applied to the treatment of low-grade ores at the Buffalo, O'Brien, and Nova Scotia mills, was used in conjunction with gravity concentration. The only all-cyanidation process used in Cobalt was developed in the Nipissing low-grade mill, which commenced operations in November, 1912. The outstanding features of the Nipissing practice are the fine grinding, the desulphurization treatment, and the use of aluminium precipitation. A description, in great detail, of this plant is given in J. Johnston's article,"The Mill and Metallurgical Practice of the Nipissing Mining Company," Chapter 1, *Mining and Engineering Transactions*, Vol. XLVIII, 1914, pages 3-32; and *Transactions Canadian Mining Institute*, Vol. XVII, 1914, page 64.

In brief outline, the practice used for a number of years was as follows: The ore from the various workings, after being broken to 4-inch cubes in gyratory crushers, was delivered to the mill bins, either by surface tramways or by a Bleichert aerial tram, stretching across Cobalt lake. On entering the mill, the ore was weighed on a Fairbanks registering scale, sized in a trommel, and given a preliminary treatment by hand-sorting and jigging. The concentrate was sent to the high-grade mill for treatment, and credited to the mine as high-grade ore. The rejects from the washing plant were crushed to one and a half inches in a No. 4 Gates gyratory, and sent to the stamp bins.

In the mill proper, the ore was crushed by forty stamps through a 4-mesh screen, in a 0.25 per cent. solution of caustic soda. Lime was added to the battery to the extent of five pounds per ton of ore, to facilitate settling and decantation of the clear solution back to the battery storage tank. Fine grinding was effected in a closed system of four tube-mills and classifiers, two of the tube-mills being used to grind the battery-discharge and the other two for the ultimate fine grinding. The tube-mills were six feet by twenty feet, lined with silex, and loaded with flint pebbles. Of the final product 2 per cent. remained on a 200-mesh screen, 26 per cent. to 40 per cent. being a fine —200-mesh sand, and the remainder an impalpable slime. After settling and decanting the solution, the thickened slime was sent on to the reducing treatment.

The pulp was given a preliminary desulphurizing treatment by passing it through a tube-mill, charged with ingots of aluminium. The final treatment was given by agitating the pulp by mechanical means for thirty-six hours in the filter stock-tank, which was lined with aluminium plates. After filtering, the cake carried 26 per cent. of alkaline solution as moisture, and was discharged without washing to the cyanide tanks.

Cyanidation was practised by the charge system, in mechanically agitated tanks. The pulp was agitated for forty-eight hours in a 0.25 per cent. solution of cyanide, with a dilution of 2.5 :1, the pulp was then settled, the excess solution decanted, and the thickened pulp sent to the stock-tank for filtering. A Butters' filter-plant was used. This was equipped with eighty leaves, and handled a charge of thirty-five or forty tons every three to four hours. The tailing discharged contained 26 per cent. of moisture. After being clarified, the pregnant solution was precipitated with aluminium dust. A continuous precipitation process was used, instead of the charge system, as developed at the O'Brien. The precipitate was collected in Merrill filter presses, and sent to the refinery of the high-grade mill. Here it was melted down and refined in a reverberatory furnace, the resulting bullion averaging 994 fine. The chief impurity was copper. which was brought down by the aluminium. The fineness was raised to 996 by re-melting with amalgam sponge from the high-grade treatment.

Using the practice as outlined above, the Nipissing low-grade mill had a daily capacity of about 230 tons. Working on a 26-ounce ore (below the stamps) the mill made an extraction of 92 per cent. of the silver values, actually recovered in bullion.

Development of Later Practice at Nipissing

For several years, following the commencement of operations in the latter part of 1912, the Nipissing low-grade mill continued to function satisfactorily, using the practice as outlined above. Early in 1915, however, changes in the character of the ore being treated, and economic disturbances resulting from the war, made certain changes in metallurgical treatment essential. Some of the more important of these changing conditions were as follows:—

Changes in the character of the ore: When the low-grade mill started operating, the ore carried appreciable amounts of the complex silver-minerals, which are difficult of solution in cyanide, but which yield readily to the desulphurization treatment. Later, the ore coming into the mill contained less of these minerals, until, with the increased cost of aluminium, the desulphurization treatment of the ore did not pay for itself in the increased amount of silver recovered by the subsequent treatment with cyanide.

Variations in the price of silver: Prices fell in 1915 to as low as 46⅝ cents an ounce, and rose later in 1919 to a maximum of $1.37¼ an ounce.

The rise in the cost of labour and supplies, including chemicals: During the war period the cost of all chemicals was greatly enhanced, the price of aluminium dust for instance advancing from nineteen cents a pound to over $1.00 a pound.

The development of a market for concentrates and residues containing cobalt and arsenic: During the war these base-metal by-products became a valuable source of revenue, the price of metallic cobalt advancing to $4.50 a pound.

To meet these varying conditions the following changes were made in the metallurgical treatment of the ore.

(*a*) In 1915 desulphurization was discontinued, owing to the change in the character of the ore and the increased cost of aluminium.

(*b*) In 1916 the all-cyanidation practice was abandoned, and an experimental flotation machine was installed to ascertain whether the silver minerals, not dissolved by the cyaniding treatment, could be recovered.

(*c*) At the same time aluminium precipitation was abandoned in favour of precipitation with sodium sulphide. A small amount of aluminium was still used to desulphurize the precipitated silver sulphide.

(*d*) As experimental work on a commercial scale with the flotation process was found to be unsuccessful after cyanidation, in the latter part of 1917 the tests were discontinued and gravity concentration was installed before cyanidation.

(*e*) The practice of gravity concentration, with extremely fine grinding, followed by cyanidation was found to be so satisfactory that in 1921 the preliminary treatment by hand-sorting and jigging was abandoned.

Present Nipissing Practice

The various changes in metallurgical treatment, indicated above, have resulted in the present Nipissing practice, which is as follows:—

Crushing and Stamping.—The run of mine ore is crushed at the mine to 4-inch cubes in 18-inch by 36-inch jaw crushers and delivered to the mill bins by surface trams or by the Bleichert aerial tram as in previous practice. At the mill, the ore is fed over a magnetic pulley to remove tramp-iron and is reduced to 1½-inch cubes in a No. 2 Bronze Ball gyratory, before being sent to the stamp bins. Stamping is done in 0.12 per cent. KCN solution, through a 4-mesh screen.

Lime is added in the battery to the amount of five pounds per ton of ore, to facilitate settling and decantation.

Concentration and Fine Grinding.—The battery discharge is concentrated on twelve No. 6 Wilfley tables, making a low-grade concentrate, which is re-cleaned on a separate No. 6 Wilfley table. The reasons for this practice have already been given in the discussion on concentration. The tailing from the tables goes direct to Dorr duplex classifiers working in closed circuit with three 6-ft. by 20-ft. tube-mills. These are lined with hard iron and loaded with flint pebbles, and discharge a product of which approximately 8 or 10 per cent. remains on a 200-mesh screen. The classifier overflow is concentrated on sixteen No. 6 Wilfley slime tables, making a low-grade concentrate, which is re-cleaned on one No. 6 Wilfley slime table. The re-cleaning tables discharge a clean high-grade product, which is loaded at intervals into a car and conveyed to a floor where it is weighed and sampled. It is then sent to the high-grade mill for further treatment.

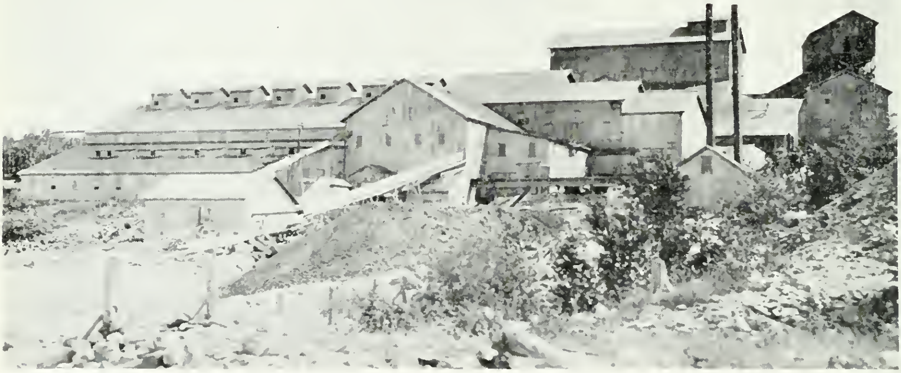


Fig. 65—Low-grade and high-grade mills, Nipissing Mining Company, Limited.

Final Sliming.—For final re-grinding, the tailing from the slime tables is pumped to two 15-ft. Dorr duplex bowl classifiers, operating in closed circuit with one 4-ft. by 20-ft. tube-mill, lined with hard iron and loaded to the centre with $1\frac{1}{4}$-inch iron balls. The plus and minus 200-mesh sands are separated by the classifier, and ground in the tube-mill until reduced to an impalpable slime. The classifier overflow, containing approximately 80 per cent. of true slime, and the remainder as a very fine sand, is sent to a Dorr thickener which feeds the agitation vats.

Agitation.—The overflow from the thickener, depending on its silver content, is sent either to the circulating tank or to the precipitation supply vat. The underflow with a dilution of 2.5: 1, is pumped by a triplex diaphragm pump direct to the agitation tanks. Cyanidation is practiced by the charge system in mechanically agitated tanks. The pulp is agitated continuously for a period of fifty hours, the cyanide strength being maintained at 0.25 per cent. The oxygen necessary for dissolution is supplied by circulating the pulp by means of a 6-inch air lift, during the treatment period. The pulp is then allowed to settle for eight hours, and the pregnant solution decanted to the precipitation storage-tank. The thickened pulp is again agitated, the depth of pulp measured, and a sample taken for calculating tonnage by specific gravity determination. The charge is then pumped to the filter storage-tank. It is interesting to note that after making due allowance for the addition of lime, pebbles, and solids in the mill solution, the calculated tonnage has checked with the weighed-in weight of this ore, over a period of eight years.

Filtering.—The pulp in the filter stock vat is agitated continuously and drawn off to the filters as required. The filter plant is arranged on a semi-gravity plan, a 10-inch centrifugal pump with hydraulically operated valves being connected with the filter-box, for handling the excess pulp and solution. A Butters filter with seventy-two leaves handles a charge of forty tons of dry slime in three and three-quarter hours. The effluent solutions are sent by means of a 12-inch by 10-inch Goulds duplex wet vacuum pump to the precipitation or circulating storage vats. The residue is flushed to the slime pond.

Precipitation and Desulphurization.—The pregnant solutions to be precipitated are delivered to a storage vat, from which they are pumped through a clarifying press in the precipitation-room by means of a 6-inch by 9-inch vertical triplex pump. The clear solution flows to the precipitation tank, where it is mixed with sodium sulphide which precipitates the silver as silver sulphide. The solution is then pumped by a 6-inch by 9-inch vertical triplex pump through a filter press, where the precipitated silver sulphide is retained. The barren solution is returned to the barren-solution tank, for further use. The silver sulphide precipitate is taken from the press every three days, and reduced to metallic silver by a desulphurizing treatment with aluminium ingots, in a solution of caustic soda. It is then sent to the refinery of the high-grade mill, where it is refined into bullion 999 fine. Details of the Nipissing practice, in precipitating, desulphurizing, and refining, are given in the discussion below.

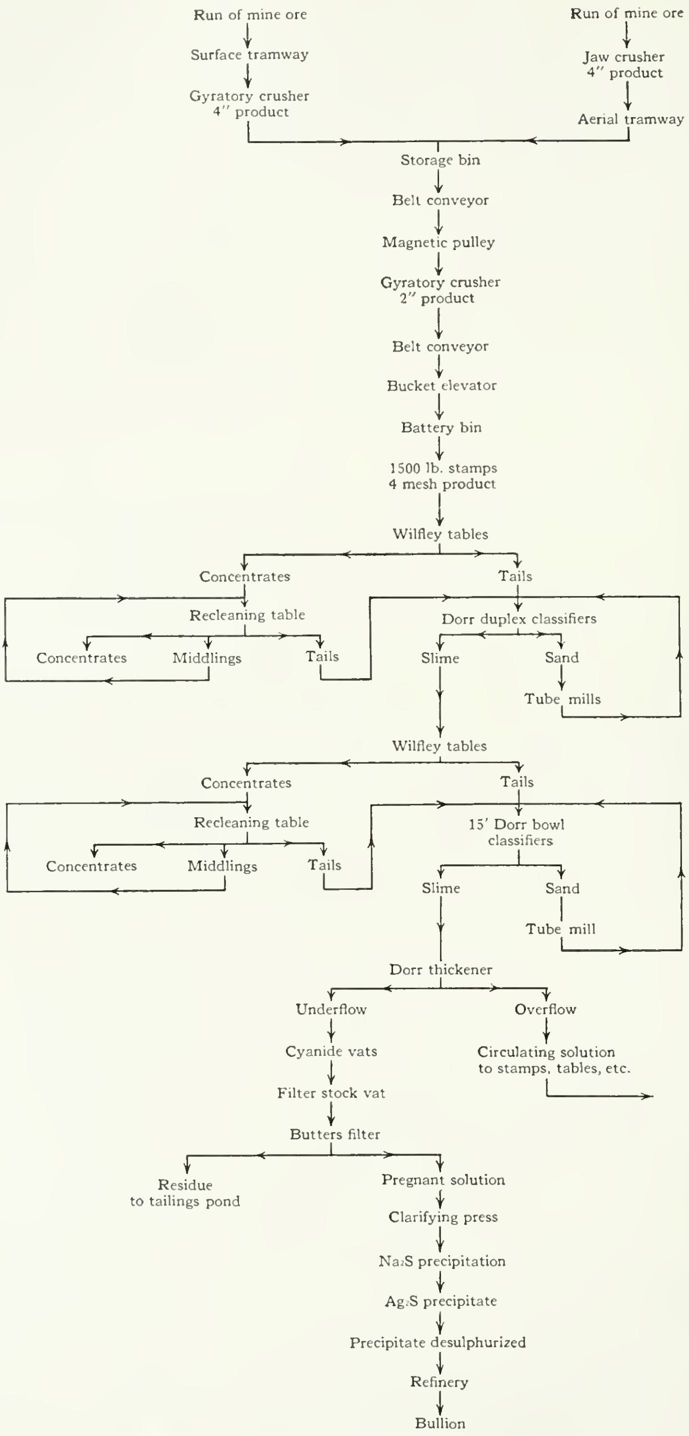
Summary of Nipissing Practice

The present Nipissing practice may be summarized as follows:—

1. Crushing run of mine ore at the mine to 4 inch in 18-inch by 36-inch jaw crushers.
2. Crushing to 1½-inch at mill in No. 4 gyratory crushers.
3. Stamping to 4 mesh by 40 1,500-pound stamps.
4. Roughing on Wilfley sand tables.
5. Fine-grinding in tube-mills to 8 per cent. plus 200 mesh.
6. Roughing fines on Wilfley slime tables.
7. Final sliming in tube-mill with 1¼-inch iron balls.
8. Agitation for fifty hours in 0.25 per cent. KCN in mechanical agitators.
9. Filtering in Butters filters.
10. Sodium sulphide precipitation.
11. Desulphurizing precipitate of silver sulphide.
12. Melting and refining to bullion 999 fine.

These operations are shown in skeleton outline in Table XXIV, which follows:—

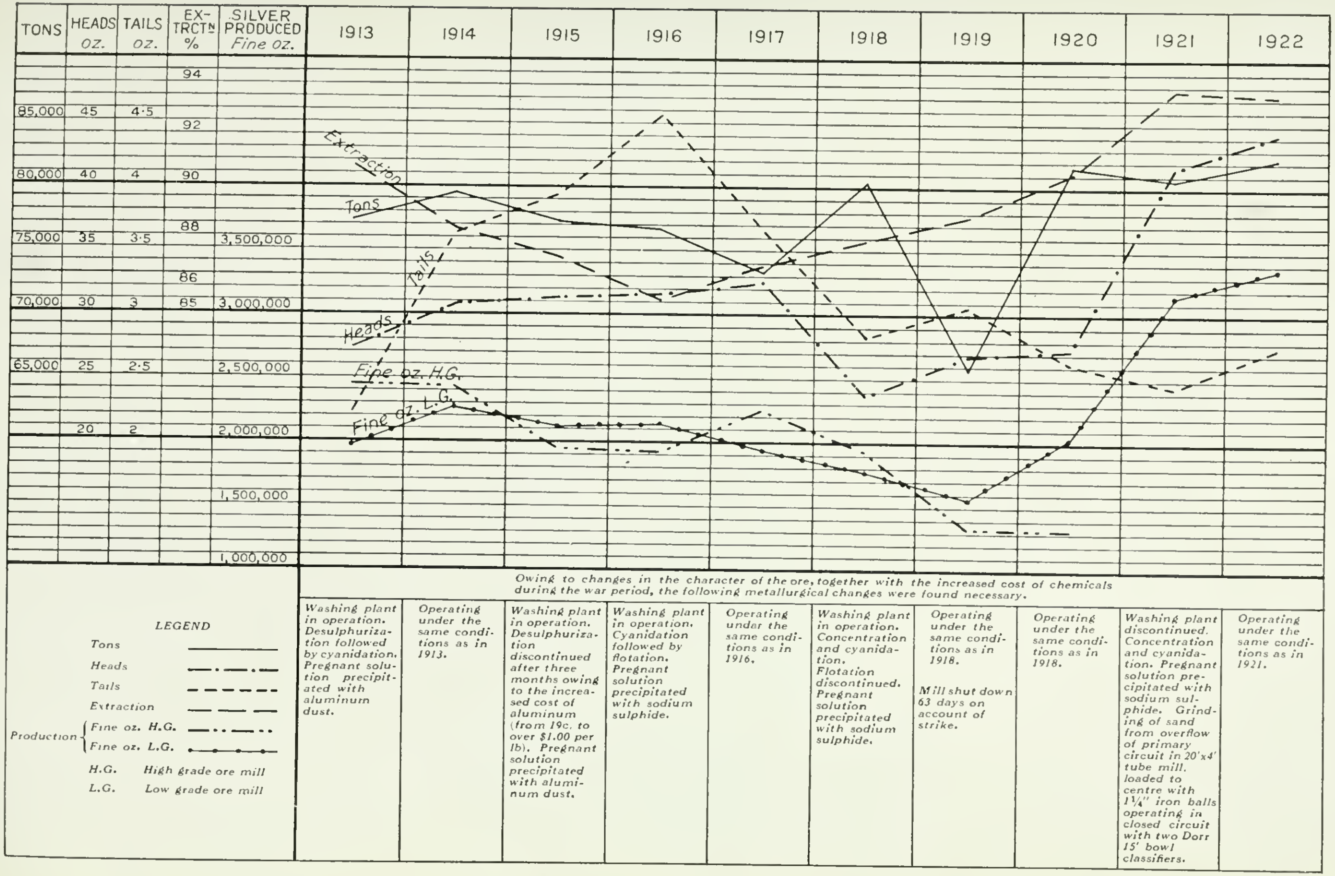
TABLE XXIV



Nipissing Mining Company, Ltd., flow-sheet of low-grade mill.

Results.—A summary of the results obtained in the Nipissing low-grade mill is given in Table XXV, which shows graphically the yearly tonnage, assay of heads and tails, and extraction, for the years 1913 to 1922, inclusive. This chart brings out very clearly the effect of the various changes in practice as already outlined.

TABLE XXV



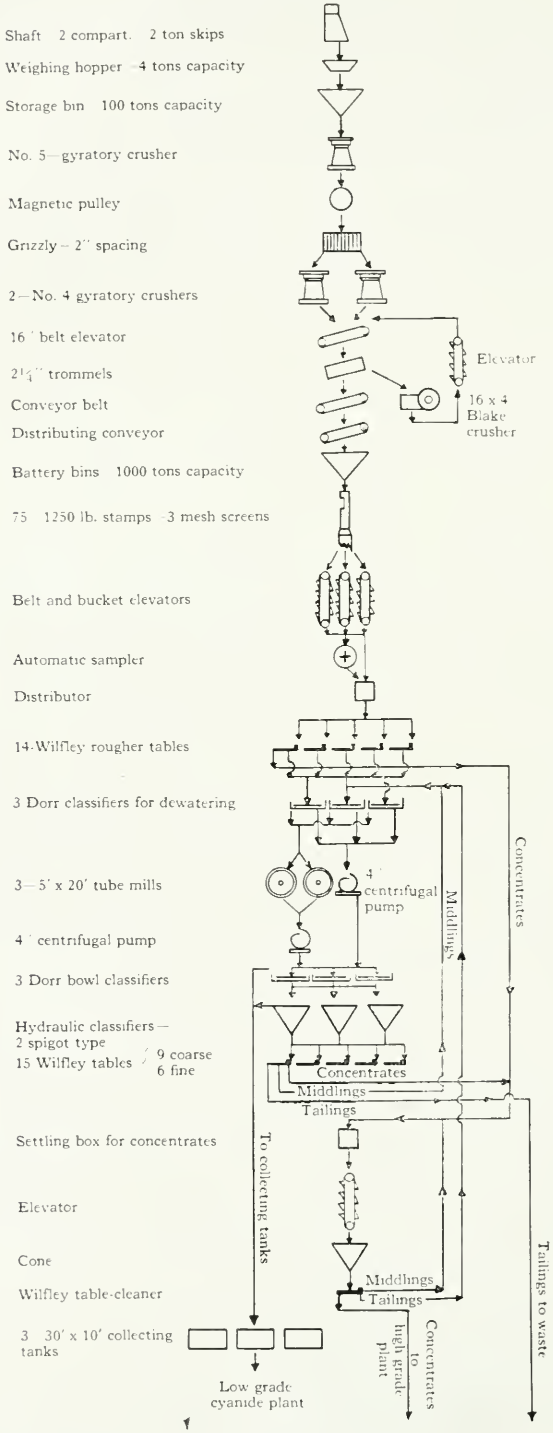
Owing to changes in the character of the ore, together with the increased cost of chemicals during the war period, the following metallurgical changes were found necessary.

1913	1914	1915	1916	1917	1918	1919	1920	1921	1922
Washing plant in operation. Desulphurization followed by cyanidation. Pregnant solution precipitated with aluminum dust.	*Operating under the same conditions as in 1913.*	*Washing plant in operation. Desulphurization discontinued after three months owing to the increased cost of aluminum (from 19c. to over $1.00 per lb). Pregnant solution precipitated with aluminum dust.*	*Washing plant in operation. Cyanidation followed by flotation. Pregnant solution precipitated with sodium sulphide.*	*Operating undar the same conditions as in 1916.*	*Washing plant in operation. Concentration and cyanidation. Flotation discontinued. Pregnant solution precipitated with sodium sulphide.*	*Operating under the same conditions as in 1918.* *Mill shut down 63 days on account of strike.*	*Operating under the same conditions as in 1918.*	*Washing plant discontinued. Concentration and cyanidation. Pregnant solution precipitated with sodium sulphide. Grinding of sand from overflow of primary circuit in 20'x4' tube mill. loaded to centre with 1¼" iron balls operating in closed circuit with two Dorr 15' bowl classifiers.*	*Operating under the same conditions as in 1921.*

(Extraction in 1913—91.85 per cent.)

Nipissing Mining Company, Ltd., Cobalt, Ontario.

TABLE XXVa



Cobalt Reduction Company flow-sheet, 300-ton plant.

Extraction.—Using the combined gravity concentration and cyanidation practice, the Nipissing low-grade mill, over a period of two years, made an extraction of 93.9 per cent., on an ore averaging approximately forty-three ounces of silver to the ton. The relative recoveries made by the different processes are shown in the following table.

TABLE XXVI.—SILVER RECOVERY AT NIPISSING LOW-GRADE MILL

Product	Total silver	Per cent. of total	
	ounces		
Coarse concentrate	4,490,341.45	64.46	93.90
Fine concentrate	207,876.47	2.99	
Cyanide precipitate	1,842,942.48	26.45	
Loss in KCN tailing	424,915.48	6.10	
Total	6,966,075.88	100.00	

The low recovery in the fine concentrate is due to the dissolution of some of the silver, during the stamping and tube-milling operations.

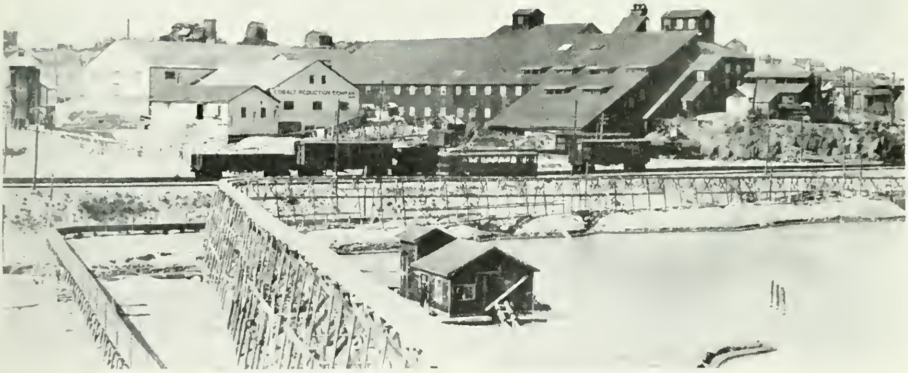


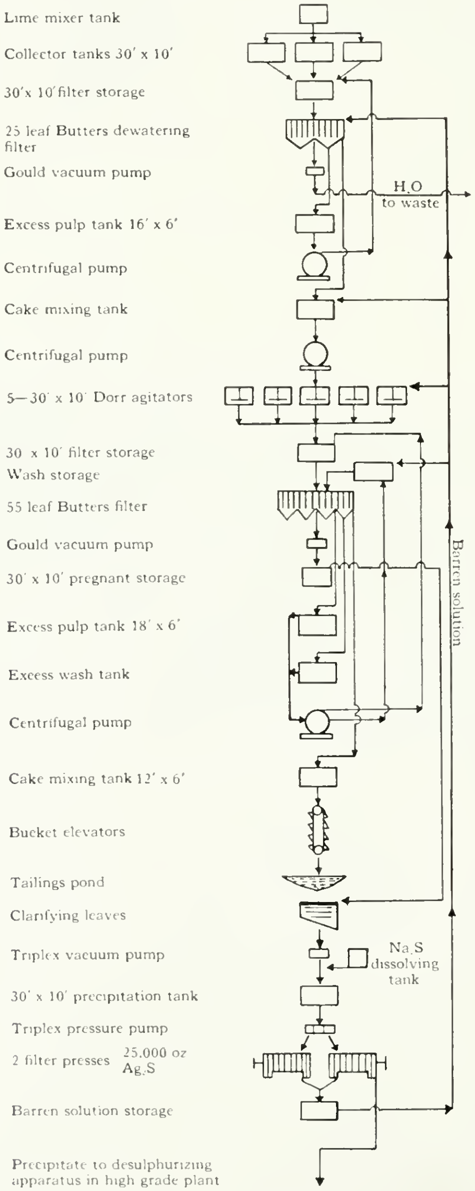
Fig. 66—Mill of the Cobalt Reduction Company.

Cobalt Reduction Company Practice

The process used at the Cobalt Reduction Company mill is gravity concentration, followed by cyanidation. This is one of the best equipped mills in the camp, and since the practice offers an interesting variation from the general procedure, a brief description of this plant is given here.

Concentration.—The run-of-mine ore is delivered to the mill bins and fed to a gyratory crusher, where it is broken to 4-inch cubes. After passing over a magnetic pulley for the removal of tramp-iron, it is conveyed to a second gyratory, where it is broken to 1½ inch. It is then delivered to the battery bins. Crushing in the battery is done with 1,250-pound stamps, in water, to pass a 6-mesh screen. The battery-discharge is sampled automatically and passed over Wilfley sand tables. The tailing is classified, the sand going direct to tube-mills, while the slime passes on to the cyanide annex. The tube-mill discharge, now ground to 40-mesh, passes to Dorr classifiers which separate it into two products, sand and slime. The sand goes to double-spigot hydraulic classifiers which eliminate all slime, making a clean sand product. This is concentrated on Wilfley slime tables, the tailing from which goes to waste. The slime from the classifiers passes to the cyanide annex. The concentrates from all tables are re-cleaned on a separate table, making a clean product which is sent to the high-grade plant for treatment. The middling is returned to the tube-mill circuit.

TABLE XXVI*a*



Cobalt Reduction Company flow-sheet, cyanide annex, 190 tons capacity.

Cyanidation.—The slimes produced by the various crushing operations amount, approximately, to 55 per cent. of the original feed to mill. Ninety-eight per cent. of this material will pass a 200-mesh screen. The slime is sampled automatically, and discharged into a collecting tank equipped with a Dorr agitator mechanism. Three pounds of lime per ton of ore are added to assist settling, and the clear water is decanted to waste. The thickened pulp passes to a Butters filter plant where it is dewatered, the cake retaining 25 per cent. moisture. This is dropped into a receiving tank, barren solution is added, and the mass thoroughly agitated. It is then pumped to Dorr agitators and given a cyanide treatment at a dilution of 2:1 for a period of fifty-five hours. The cyanide strength is maintained at 0.25 per cent. KCN. After treatment the pulp passes to a storage tank, which feeds the Butters filter. After filtering, the cake is washed with barren solution, and discharged to waste. The pregnant solution is clarified by vacuum filters, and the silver precipitated by the charge-system with sodium sulphide, the precipitate being desulphurized with aluminium. The precipitation practice is similar to that of the Nipissing which is described later.

Summary.—The points of greatest interest in the Cobalt Reduction Company practice are:—

1. Concentration in water.
2. Separation of sand from slime—45 per cent. of the total feed is ground to 40 mesh and concentrated, the tailing going to waste; 55 per cent. of the total feed, ground to 200 mesh, is treated by cyanidation
3. Treatment of high-grade ore and table concentrates by the hypochlorite cyanidation process. This plant is described in a later section discussing the treatment of high-grade ore.

Recovery.—The results obtained at the Cobalt Reduction Company's plant are shown in the following table:—

TABLE XXVII.—PRODUCTION CHART OF COBALT REDUCTION COMPANY

Schedule	Years 1917 and 1918	Per cent.	July 1, 1921, to June 30, 1922	Per cent.
Tons treated	125,845	....	96,509	....
Average assay, oz. per ton	38.53	....	18.07	....
Ounces contained	4,849,077	....	1,743,949	....
Tons concentrate	1,847.74	....	656.90	....
Average assay, oz. per ton	2,021.17	....	1,729.87	....
Ounces contained	3,734,603	77.02	1,136,351	65.16
Tons cyanided	70,952	....	51,729	....
Average assay, oz. per ton	13.23	....	9.21	....
Ounces contained	939,046	....	476,485	....
Ounces recovered	775,320	15.99	376,966	21.62
Total ounces recovered	4,509,923	93.01	1,513,317	86.78
Tailing (ounces)	339,154	6.99	230,632	13.22

Additional Notes

Dissolution.—Extremely fine grinding of the ore is essential to dissolution of the silver values in a reasonable time of treatment. The failure to appreciate this fact was one of the principal reasons for the poor extraction obtained in some of the earlier work. The degree of comminution required varies with the amount of antimony present. Metallic silver containing antimony dissolves very slowly in cyanide solution, as do also the complex silver-minerals, unless they are ground very fine.

The ore is strongly reducing. This is due to the presence of soluble compounds of sulphur, arsenic, and antimony, e.g., sulphides, arsenites, antimonites, etc. These soluble compounds are oxidized to thiosulphates, arsenates, and antimonates, etc., by the dissolved oxygen, with the result that the dissolving efficiency of the solution is greatly impaired. A large amount of air must be supplied to prevent the solution being robbed of its dissolved oxygen.

Desulphurization.—The object of this treatment was to decompose the complex silver-minerals into their respective elements, leaving the silver in a spongy metallic state, in which condition it was readily amenable to cyanide treatment. This was accomplished by bringing the ore into direct contact with aluminium in a solution of caustic soda. The method of applying this treatment, in actual operations, has already been given in the discussion of earlier Nipissing practice. A complete description of the process is given in the paper by J. J. Denny, "Desulphurizing Silver Ores at Cobalt," *Mining and Scientific Press*, September 27th, 1913.

At the Nipissing low-grade mill, desulphurization was practised for several years. It was discontinued in 1915, when the change in the nature of the ore and the increased cost of aluminium rendered it commercially ineffective. Desulphurization is still used in the reduction to metallic silver of the silver sulphide resulting from sodium sulphide precipitation. This is discussed below.

Costs and Extraction.—In the early Nipissing practice, desulphurization of the ore then being treated resulted in an increased extraction of one to four ounces of silver, at the cost of one ounce. Detailed costs of treatment, taken from the article by J. J. Denny, already referred to, are given in the following table:—

TABLE XXVIII.—COST OF DESULPHURIZING TREATMENT

Collecting, desulphurizing, and transferring of pulp:—		
		Per ton
Labour		$0.050
Supplies—Aluminium	0.81 lb.	0.347
Caustic soda	1.4 "	
Lime	5. "	
Power		0.027
Workshop		0.008
Total		$0.432
Alkali solution, filtering and transferring:—		
		Per ton
Labour		$0.069
Supplies		0.006
Power		0.028
Workshop		0.002
Total		$0.105
Total cost of treatment		0.537

Agitation.—Agitation during the cyanidation treatment is carried on in tanks of various forms and designs. These include the Dorr agitator, Pachuca tanks, and agitators of the mechanical stirrer type. Of these the Dorr agitator is considered the most satisfactory, owing to its simplicity, low power consumption, and the absence of mechanical trouble. In the cyanidation of these ores a high dilution is desirable, the treatment of 20-ounce ore requiring a dilution of 2:1 or more. Since subsequent settling and decantation of the clear solution is not possible, a high dilution cannot be used in the Pachuca tank without throwing a heavy load on the filtering plant.

Filters and Filter Presses.—Vacuum filters of the Butters and Moore type are used in all the mills. The Dominion Reduction and the O'Brien mills use the Moore filter. The Butters filter is used at the Nipissing and Cobalt Reduction plants.

The filtering cycle of the Nipissing low-grade mill, shown in the following table, is indicative of the general practice.

Table XXIX.—Filtering Cycle at the Nipissing Low-Grade Mill

	Minutes
Filling filter box with stock pulp	5
Period vacuum applied	60
Pumping back excess pulp	8
Pumping in solution wash	6
Time washing	90
Pumping back solution wash	6
Pumping in water wash	6
Time water washing	18
Pumping back water wash	6
Discharging residues	20
Total time of filtering cycle	3 hrs. 45 min.
Thickness of cake	1¾ in.
Specific gravity of pulp	1.3
Tons of dry slime filtered	40

The filter presses used are of various designs. The Nipissing and Dominion Reduction use the regular Merrill triangular filter press for clarifying the solution and collecting the precipitate. The Cobalt Reduction use the Perrin press. The O'Brien used a Perrin press for clarifying, and a Schriver press for collecting the precipitate. Between these various machines there is little choice; all operate on the same mechanical principle, and give equally satisfactory results.

Precipitation

Three distinct methods for precipitating silver have been used in the cyanidation of Cobalt ores. These are:—

1. Precipitation with zinc,
2. Precipitation with aluminium,
3. Precipitation with sodium sulphide.

Precipitation with zinc.—At the Buffalo mill precipitation was effected by zinc-shavings, using three wooden boxes of the ordinary type. At the Dominion Reduction mill, zinc dust was used, with a regular Merrill triangular filter press for collecting the precipitate. The Nipissing low-grade mill was originally designed for precipitation with zinc dust, but after investigation the system of precipitating with aluminium was adopted before the mill started to operate.

The use of zinc as a precipitant, in a solution containing appreciable amounts of arsenic and antimony, was found to be very unsatisfactory. In addition to causing a heavy consumption of cyanide, the zinc fouled the solution, resulting in a marked decrease in dissolving efficiency. A comparison of zinc with aluminium, as a precipitant of silver from cyanide solution, is given in the following discussion.

Aluminium Precipitation.—Precipitation by aluminium was developed by S. F. Kirkpatrick, who applied it in a commercial way to the cyanidation of Cobalt ores, first at the Deloro smelter, and later at the O'Brien mill in Cobalt. Its advantages over precipitation by zinc were later fully investigated by the metallurgists at the Nipissing before its adoption in the low-grade mill. The subject is covered fully in the articles by J. J. Denny[1], E. M. Hamilton[2], and S. F. Kirkpatrick[3]. Details of the practice used at the Nipissing and O'Brien mills are given in E. M. Hamilton's article.

The advantages of aluminium precipitation are as follows:—

(1) No fouling of the solution, and no loss of dissolving efficiency, but rather the reverse. The working-solution showed an increased dissolving power of 0. 35 ounces of silver per ton of ore, over a freshly made solution.

(2) A regeneration of cyanide, instead of a heavy consumption. Unlike zinc, aluminium forms no cyanogen compound, and in addition actually regenerates the cyanide combined with the silver. In the Nipissing mill, this regeneration amounted to 0. 608 lbs. of KCN per ton of solution, or 1. 67 lbs. of cyanide per ton of ore treated, equal to 408 lbs. of cyanide a day.

(3) The recovery of the silver as a clean high-grade precipitate, averaging 27,000 ounces to the ton, or about 930 fine. The barren solution is reduced to about 0. 05 ounces of silver to the ton.

Cost of Aluminium Precipitation.—The following data showing the relative costs of precipitation by aluminium and zinc are taken from the article by E. M. Hamilton, already referred to.

> The present price of aluminium dust, laid down at the Nipissing, is 38 cents per pound, and of zinc dust 7 cents per pound. The consumption of aluminium is 0.02 pound, and of zinc dust 0.1 pound, per ounce of silver precipitated, on an ore yielding 20 ounces of silver to the ton. The relative costs would be as follows:—

TABLE XXX.—COMPARATIVE COSTS OF ZINC AND ALUMINIUM PRECIPITATION

Aluminium dust		Zinc dust	
0.4 pound aluminium at 38 cents.....	$0.152	2 pound at 7 cents............	$0.14
1.5 pound caustic soda, 2¼ cents.....	0.033		
Per ton....................	$0.185		$0.14

> In the figure for caustic soda, 0.5 pounds has been allowed for chemical consumption and 1 pound for mechanical loss. To offset the extra charge of 4½ cents per ton of ore, there would be a direct recovery of 9.6 pounds of KCN at 15 cents or $0.24 per ton; a further saving in cyanide due to the absence of any action between the precipitant and the cyanide; a saving in the cost of milling and refining, and in some cases, of marketing the bullion. In addition there is a gain in extraction of from 7 per cent. to 14 per cent.

The equations given for the precipitation of silver by aluminium are as follows:—

$$2\ NaAg(CN)_2 + 4NaOH + 2Al = 4NaCN + 2Ag + Na_2Al_2O_4 + 2H_2$$

According to this equation, one part of aluminium would precipitate four times its weight of silver. In practice, the proportion is found to be about three of silver for one of aluminium.

Analysis of Precipitate.—The following tables give analyses of the precipitates obtained at the Nipissing and Dominion Reduction mills:—

---

[1] J. J. Denny, Mining and Scientific Press, September 27th, 1913.

[2] E. M Hamilton, Engineering and Mining Journal, May 10th, 1913.

[3] S. F. Kirkpatrick, Engineering and Mining Journal, June 28th, 1913.

TABLE XXXI.—ANALYSIS OF SILVER PRECIPITATE BY ALUMINIUM DUST AT NIPISSING MILL

	Per cent.
Silver	89.92
Sulphur	0.84
Lime	1.07
Iron	0.95
Mercury	0.48
Aluminium	0.56
Copper	0.36
Arsenic	0.48
Antimony	0.64
Nickel	0.16
Lead	0.08
Bismuth	0.03
Zinc	0.06
Cobalt	trace
Silica and insoluble	2.98

TABLE XXXII.—ANALYSIS OF SILVER PRECIPITATE BY ALUMINIUM DUST AT DOMINION REDUCTION COMPANY MILL

	Per cent.
Silver	88.04
Silica	3.50
Copper	0.78
Iron	1.84
Cobalt	0.13
Nickel	0.16
Aluminium	0.84
Lime—CaO	1.04
Arsenic	2.41
Lead	0.65
Sulphur	0.27
	99.30

Sodium Sulphide Precipitation.—The present practice of precipitation by sodium sulphide was developed in 1916 at the Nipissing mill, to replace aluminium precipitation, and like the former practice, it soon became general in the camp. The change was made urgently necessary as a result of the changes in economic conditions wrought by the war. Before the war, aluminium dust cost 33.82 cents per pound and caustic soda 2.11 cents per pound, laid down at the mine. In May, 1916, the price of aluminium dust was advanced to 90 cents, and caustic soda to 5.77 cents per pound. At these prices, the increased cost of these two chemicals amounted to about $33,000 a year. Although developed to meet an emergency, the present practice has been so satisfactory that it will be permanently retained. A complete description of the process and the Nipissing practice is given in the article by R. B. Watson, "Sodium Sulphide Precipitation of Silver at the Nipissing Mine," Transactions of the Canadian Mining Institute, Vol. XX, 1917, from which are taken many of the data here given.

The sodium sulphide process involves the precipitation of the silver as silver sulphide, the reduction of the precipitate to metallic silver by a desulphurizing treatment, and the melting down of the resulting silver to fine bullion.

At the Nipissing, precipitation is effected in two wooden tanks, 5 ft. by 6 ft., provided with mechanical agitation. In the first tank the clarified solution meets a small stream of concentrated sodium sulphide, which throws down the silver sulphide as a fine precipitate. To avoid blinding the canvas, the precipitate is caused to agglomerate by agitating it in the second tank, before it is drawn off to the filter press. In practice it is found that 0.06 lbs. of sodium sulphide (60 per cent. strength) are required to precipitate one troy ounce of silver. Gold is not precipitated at all, nor is copper, if the solution contains not less than 0.15 per cent. of free cyanide. As with aluminium, precipitation by sodium sulphide regenerates all the cyanide combined with the silver in the pregnant solution. The reactions involved are shown in the equation:—

$$2\ NaAg\ (CN)_2 + Na_2S = Ag_2S + 4\ Na\ CN.$$

A press full of sulphide precipitate contains about 23,000 ounces of silver.

Treatment of Precipitate

O'Brien Practice.—To reduce the precipitate of silver sulphide to metallic silver, several processes were developed at the O'Brien mill. These are, briefly, as follows:—

(1) The precipitate was melted and cast into anodes which were electrolysed in a solution of caustic soda, using carbon cathodes.

(2) The silver sulphide was melted in crucibles with scrap iron, yielding a base bullion and an iron matte, which carried appreciable amounts of silver. These were shipped to the company's smelter at Deloro.

(3) The latest practice, used up to the time of the destruction of the mill by fire (Sept., 1922), was to fuse the silver sulphide with aluminium ingots in a Harvey tilting furnace. By this treatment one pound of aluminium will refine twelve pounds of silver, yielding a bullion up to 980 fine, and a slag of aluminium sulphide; 5 per cent. of the silver enters the slag. About four tons of slag are accumulated in a year, from the treatment of about 250,000 ounces of silver.

Nipissing Practice.—At the Nipissing, the precipitate is reduced to metallic silver by a modified form of the desulphurizing process, already described in the treatment of the ore.

The precipitate of silver sulphide is transferred to an iron tank 7 ft. by 5 ft., provided with a mechanical agitator. Aluminium ingots, weighing 500 lbs., are thrown in, and caustic soda is added, about 0.03 lbs. of 76 per cent. caustic soda being required for every ounce of silver. With a dilution of 4:1 the solution has a strength of about 8 per cent. NaOH. The mixture is agitated until the black silver sulphide turns brown. This requires about eight hours, depending upon the temperature of the solution. The caustic solution must not be too hot, as the reaction with the aluminium will then become too violent. This will interfere with the reduction of the silver sulphide, as the large amount of hydrogen given off prevents the actual contact necessary between the sulphide and the aluminium. The desulphurized precipitate is collected in a filter press, washed free of sodium sulphide, and delivered to the refinery. The ingots remaining are left in the bottom of the tank for the next charge. The reactions involved are shown in the following equation:—

$$2\ Al + 8\ NaOH + 3\ Ag_2\ S = Na_2\ Al_2\ O_4 + 3\ Na_2S + 6\ Ag + 4\ H_2O$$

Samples taken of the silver sulphide precipitate, before and after treatment, are assayed for silver. The increase in silver after desulphurizing is approximately 3,000 ounces. If the pregnant solution is well clarified before precipitation, it is possible to make a product, after desulphurizing, that will assay 27,000 ounces. Analyses of the precipitate, before and after desulphurizing, are given in the following table, from the article by R. B. Watson, already referred to.

TABLE XXXIII.—ANALYSIS OF SILVER SULPHIDE PRECIPITATE, BEFORE AND AFTER DESULPHURIZING

	Before desulphurizing per cent.	After desulphurizing per cent.
Ag	81.21	91.72
S	12.09	0.58
Soluble in water	2.02	0.52
Insoluble in acid	2.63	3.03
FeO	0.46	0.57
Al_2O_3	1.32	1.55
CaO	0.44	0.49
MgO	0.14	0.16
Hg	0.10	0.11
	100.41	98.73

The precipitate contains no Au, Cu, Bi, Co, Ni, or Zn.

Refinery.—The desulphurized precipitate is weighed in lots, as received from the mill, and samples taken to determine the moisture and silver content. It is then charged to the reverberatory refinery furnace and melted down without flux, yielding a bullion 999 fine. During the refining the impurities are skimmed off by the operator, with a rake. These skimmings are accumulated from one to two months and melted down in a small blast furnace. The resulting base bullion is melted down with the next lot of precipitate. The slag from the blast furnace is weighed and assayed for silver and delivered to the high-grade mill, where it is given the same treatment as the concentrates. The time required for refining approximately 35,000 ounces varies from twenty-four to thirty-six hours. The fine bullion is ladled from the furnace and cast in iron moulds, to bars of about 1,200 troy ounces.

Treatment of Skimmings.—From forty-three lots of precipitate, charged to the reverberatory furnace, the following table shows the silver content of the various products from the treatment of the skimmings in the blast furnace.

TABLE XXXIV.—SILVER CONTENT OF PRODUCTS FROM SKIMMINGS TREATED IN BLAST FURNACE

		Silver content
Total weight of precipitate melted and refined in reverberatory furnace	66,308 pounds	832,308.57 oz.
Skimmings produced	8,947 "	52,721.84 "
Skimmings by weight	13.49 per cent.	6.33 per cent.
Silver content of skimmings		40.42 "
Slag and speiss produced in blast furnace	4,020 pounds	1,991.06 oz.
Slag and speiss produced in blast furnace by weight	6.06 per cent.	0.24 per cent.

Owing to the richness of the skimmings, practically no flux need be added for smelting. The furnace charge is made up by mixing the skimmings with about 15 per cent. by weight of coke and a small amount of speiss, which acts as a wash. The products from the furnace are slag, speiss, and a base bullion which assays about 850 fine.

Annual Clean-up.—The reverberatory furnace is in practically continuous operation for one year, very little patching being required to keep it in good shape. At the end of the year it is broken down and re-built, in order to make the annual clean-up. After treating between three and four million ounces of silver during the year, the amount of silver recovered from the brick and pan-bottom is less than 2 per cent. Over a period of three years, the consumption of fuel oil for 1,000 ounces of refined silver bullion was 11.5 gallons.

Sampling Milling Ore

At the Nipissing mill the ore is sampled by hand by taking samples of the stamp-battery discharge every half-hour over a period of twenty-four hours.

When grinding in cyanide solution containing dissolved silver, this system of sampling is not accurate, in spite of corrections for dilution and solution assay. Errors are due both to dissolution of silver by the cyanide solution in the battery, and to re-precipitation of dissolved silver by the action of cyanicides present in the ore. On treating clean ore, about three ounces of silver are dissolved in the battery and the recovery is higher, by this amount, than the amount of silver indicated by the heads. Re-precipitation of the dissolved silver is caused especially by decomposed nickel minerals. At one time it was thought that carbon might be the offender, as some ores contain carbonaceous slates, but a few tests showed that the material does not act as a precipitant of silver from cyanide solutions. On treating ores containing decomposed nickel minerals, about three ounces of silver are re-precipitated in the battery. Under these conditions the heads appear to be high and the extraction of silver low. The range of error is thus about six ounces in a 45-ounce head sample.

Sampling of Table Concentrates

The results from the sampling of table concentrates at the Nipissing Mill are interesting. The following figures show the comparative results of sampling by hand and mechanically, a total weight of 3,652 tons of wet table concentrates, containing 7 per cent. moisture. Hand sampling was carried out by quartering lots of six tons before charging into a 4 ft. by 25 ft. tube-mill. The feed was ground for twenty-three hours with iron balls, at a dilution of 1:1, to pass a 200-mesh screen. It was then dumped into a tank where it was diluted to 7:1 with water, and classified. The classifier overflow was sampled by an Elmore sampler located in the launder, twelve feet from the classifier. The pulp was sampled by another automatic sampling device, which cut samples from the launder as the pulp was discharged into a receiving tank. The results are shown in the following table:—

TABLE XXXV.—SAMPLING WET TABLE CONCENTRATES BY HAND AND ALSO AUTOMATICALLY

Quartering method (4-mesh product)	Oz. per ton	1362.95
Automatic method (200-mesh product) (after allowing for dilution by foreign matter)	Oz. per ton	1262.19
Difference in favour of quartering method	100.76 oz.	7.39 per cent.

The silver, recovered as fine bullion, checked with the quartering method.

Aero-Brand Cyanide

Aero-brand cyanide was used in the camp for three years. During this time it did good work and showed a saving over 98 per cent. sodium cyanide, which was then selling at an advanced price. Aero-brand cyanide is high in lime, which it was found necessary to eliminate by adding soda ash to the mill solution. In the treatment of Cobalt ores a high lime is objectionable, as it has a tendency to retard the activity of the solution, with a consequent decrease in the extraction of silver. This effect is due either to the increased viscosity of the solution, which interferes with the migration of the ions, or to the reaction of CaO with some other compound in the solution.

As 98 per cent. sodium cyanide is easier to handle, the use of Aero-brand cyanide was discontinued when, as a result of declining price, the cost of Aero-brand, together with the soda ash, showed no advantage over the 98 per cent. product. Aero-brand does good work elsewhere, when used with zinc precipitation, owing to the precipitation of the lime as calcium zincate. Carbon dioxide from the atmosphere also precipitates some of the lime as calcium carbonate. Comparative analyses of the barren working-solutions from the treatment of these ores by 98 per cent. sodium cyanide and Aero-brand cyanide, are shown in the following table:—

TABLE XXXVI.—COMPARATIVE ANALYSIS OF BARREN WORKING-SOLUTIONS, USING 98 PER CENT. SODIUM AND AERO-BRAND CYANIDE

Analysis made January 20, 1916, NaCN and Al dust precipitation.

	Low-grade solution
Specific gravity	1.007
	Per cent.
Total solids	1.190
Free KCN	0.212
Total KCN	0.303
Alkali	0.180
KCNS	0.080
Cu	0.060
Ni and Co	0.010
Al	0.020
Fe	0.001
As	0.050
Sb	0.040
CaO	0.016

Analysis made May 14, 1920, on high and low-grade solution using Aero-brand cyanide and sodium sulphide precipitation.

	High-grade solution	Low-grade solution
Specific gravity	1.0571	1.0115
	Per cent.	Per cent.
Total solids	8.304	3.596
Total cyanogen	1.13	0.42
Free cyanide (KCN)	0.47	0.22
Alkali before removing CO_2	1.33	0.30
Alkali after removing CO_2	0.89	0.20
Lime (CaO)	0.04	0.04
Fe.	0.03	0.01
Ferrocyanide	0.18	0.07
Thiocyanate	0.12	0.09
Chlorine	1.44	0.70
Cu	0.31	0.16
Ni and Co	0.04	0.02
Magnesia	0.01	0.01
Sodium	1.96	0.62
Silver	.80 oz.	.28 oz.
Carbon (floating or in suspension)	none	

The Flotation Process

Introduction

Various small scale tests were made with the Flotation Process in Cobalt prior to 1915, but the results of these were largely unsatisfactory. One of the principal difficulties was that the concentrates produced were low in grade, assaying only from thirty to fifty ounces of silver to the ton. Unfortunately no attempt was made to re-clean these low-grade concentrates, as otherwise a satisfactory process might possibly have been developed sooner.

In October, 1915, the Buffalo Mines, Limited, built an experimental flotation plant, capable of working on a tonnage scale. The machines used were of the Callow pneumatic type. The experimental work in this pioneer plant was under the direct personal supervision of J. M. Callow, who furnished experienced operators to take charge of the work. The treble-length Callow cell was here developed to meet local conditions, since, to obtain the best results, the Cobalt ores require a relatively long treatment. The adaptation of the flotation process to the treatment of the Cobalt ores was a direct result of the research work carried on at the Buffalo experimental plant.

The following September, the Buffalo Mines began to operate a Callow flotation plant, having a daily capacity of 600 tons, treating the current tailing from the gravity concentration plant, in addition to re-treating a large tonnage of similar tailings that had accumulated on the property.

The success of these plants soon led to the general adoption of this process and similar plants were built by the McKinley-Darragh-Savage Mines, the Coniagas Mines, The Dominion Reduction Company, the Northern Customs Concentrator, and the National Mines. In addition to these an experimental plant was operated by the Nipissing Mines over a period of one year, to determine whether the process could be used to advantage for the re-treatment of the tailings from the cyanide plant. The combined daily capacity of these plants was, approximately, 2,000 tons.

General Outline of Cobalt Practice

Oil Mixtures.—The flotation plants in Cobalt use an oil mixture of pine oil, coal tar creosote, and coal tar. This mixture, in the proportions of 15 per cent. pine oil, 75 per cent. coal tar creosote, and 10 per cent. coal tar, was adopted as a result of the research work done at the Buffalo experimental mill, and with variations in the amounts of pine oil and creosote, has been used by all the other mills. Many other oils and mixtures of oils have been tried, both in the laboratory and in large scale tests under mill conditions, but this particular combination has been found to be the most satisfactory. At the Coniagas mill it has been found good practice to sulphidize the oil mixture by distilling it under pressure with sulphur. The proportions used are 25 per cent. of No. 350 pine oil, 65 per cent. creosote, and 10 per cent. coal tar, together with 2½ per cent. sulphur. The oil mixture is added to the tube-mill in amounts varying from ¾ to 1½ lbs. per ton of ore treated. The amount of oil required will vary with the dilution of the pulp, the amount of mineral present, the fineness of the product being treated, and the skill of the operator.

Concentration and Grinding.—It may be said in general that the silver content of the tailing from the flotation process varies directly with the value of the feed to the cell. For this reason it has been found good practice to recover as much of the silver as possible by gravity concentration, before treatment by flotation. The tailings from the preliminary concentration treatment are ground in tube-mills, usually to 80 to 100 mesh, depending on the character of the ore. At the Coniagas mines, the practice is to grind to pass to 60-mesh screen. The oil mixture is added in the tube-mill, as a thorough emulsification of the oil is essential to good results. Care is taken also to screen out all chips and wood-pulp, as this material is found to interfere seriously with successful work. After grinding, the ore is given a final concentration on slime tables, before passing to Dorr thickeners or Callow cones. The thickened pulp is then pumped either to a mechanical mixer, where it receives an additional oiling, or direct to the flotation cells. The overflow from the thickeners is practically clear water. This is either discarded or is pumped back to be used over again in the circuit.

The Flotation Cells.—The treble-length Callow pneumatic cell, either single or double compartment, is used throughout the camp as a roughing cell. These are twenty-seven feet long and twenty-four inches wide, and are supplied with air at from four to six pounds pressure. The dilution of the feed is from 3 to 5:1, a low dilution being necessary to yield a low tailing. The rougher cell discharges a low-grade concentrate, assaying about fifty ounces of silver to the ton, which goes to the cleaner cells, and a tailing, assaying from one to two ounces of silver to the ton, which is sent to waste.

The cleaner cell is a single length Callow pneumatic cell 9 ft. by 24 inches, similar in detail to the rougher cell. The concentrate from the rougher cell is treated at a dilution usually from 15 to 20:1, without any further addition of oil. The high dilution is required to make a high-grade concentrate. A device, commonly adopted to assist in raising the grade of the concentrate, is to build up the sides of the cell to within six inches of the lower end, in order to restrict the overflow. It has also been found by some operators that, by adding sodium carbonate or sodium silicate to the cleaner cell circuit, a much higher grade of concentrates can be produced. The final concentrate usually assays from 300 to 600 ounces of silver to the ton.

Treatment of the Middling.—The tailing from the cleaner cell is called the middling. This material is not a true middling, but consists largely of a mixture of oiled particles of free mineral and rock matter, together with the true middling. It amounts to approximately 8 per cent. of the original feed, and assays from ten to thirty ounces of silver to the ton, varying with the grade of the current ore. The treatment of this product is a disputed question and has led to a considerable variation in practice. Some operators treat it by the cyanide process, others re-clean it several times in a separate circuit and finally discard a tailing containing from three to five ounces of silver to the ton, which joins the tailing from the roughing cells; others again return the middling to the head of the rougher cells with the chance of lowering its silver content before it is finally discarded with the tailing from the rougher cells. The objection to the latter course is that the high dilution of the middling disturbs the control of the rougher cell, where a low dilution is essential to the production of a low tailing. Hence the advantage of cyaniding this product or of treating it in a separate circuit.

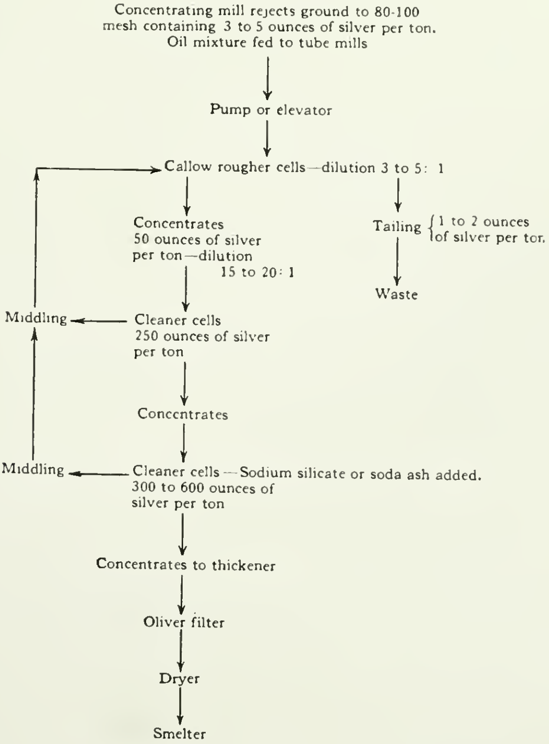
Treatment of Concentrate.—The general practice is to settle the concentrates in Dorr thickeners, filter the thickened discharge on Oliver continuous filters, and finally dry on steam coils. The product, still carrying 5 per cent. moisture, is bagged and shipped to the smelter.

Summary.—The points essential for the best results in floating the Cobalt ores are as follows:—

1. The removal of as much of the value as possible by gravity concentration.
2. The emulsification of the oil in the tube-mill.
3. The removal of chips and wood pulp.
4. A low dilution—3:1—in the rougher cell in order to get a low tailing.
5. A high dilution—15 to 20:1—in the cleaner cell to get a high-grade concentrate.

A skeleton flow-sheet of the mills using gravity concentration, followed by flotation, is as follows:—

TABLE XXXVII


Concentrating mill rejects ground to 80-100 mesh containing 3 to 5 ounces of silver per ton. Oil mixture fed to tube mills
Pump or elevator
Callow rougher cells—dilution 3 to 5: 1
Concentrates 50 ounces of silver per ton—dilution 15 to 20: 1
Tailing {1 to 2 ounces of silver per ton
Waste
Middling
Cleaner cells 250 ounces of silver per ton
Concentrates
Middling
Cleaner cells—Sodium silicate or soda ash added. 300 to 600 ounces of silver per ton
Concentrates to thickener
Oliver filter
Dryer
Smelter

Flotation flow-sheet of general practice.

The Coniagas Practice

The details of the froth flotation process, as applied to the concentration of Cobalt ores, are well exemplified in the following description of the practice used at the Coniagas plant.

Concentration and Grinding.—The battery discharge, without classification, receives a roughing treatment on Deister sand tables, making a low-grade concentrate, which is re-cleaned, and discharging a low-grade tailing which goes to a large drag classifier. The overflow from the classifier is pumped to a system of fourteen 8-ft. Callow cones, having ⅜-inch discharge spigots. The spigot discharge is further treated by being passed over three Deister slime tables. The low-grade concentrate from these tables is re-cleaned, and the tailing is sent to the flotation sump.

The discharge from the Drag classifier goes to a 5 ft. by 22 ft. tube-mill, loaded with ten tons of 4-inch metallic (white iron) pebbles. The oil mixture is added to the tube-mill and is ground with the ore, the oil consumption being less than one pound per ton of ore treated. The tube-mill discharge passes a a Dorr simplex classifier, the overflow of which goes to the flotation sump. The sand discharge from the classifier is carried by a spiral conveyer to a second tube-mill, 5 ft. by 22 ft., loaded with ten tons of 1½-inch white iron pebbles. A further addition of the oil mixture is made in this mill. The pulp, now ground to pass to 60-mesh screen, receives a further treatment on four No. 3 Deister slime tables, the concentrate from which is finished on a re-cleaning table. The tailing is discharged to the flotation sump.

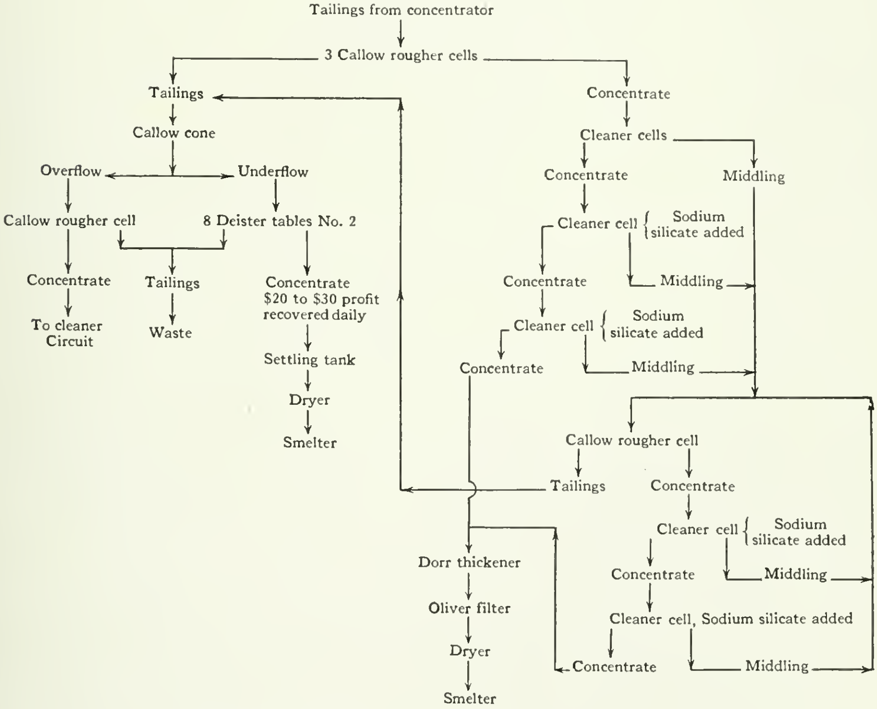
The Primary Rougher Circuit.—The pulp is lifted from the flotation sump by a 6-inch centrifugal pump, to a distributor head-box in the flotation plant, and passes, at a dilution of 4:1, into three treble-length, double-compartment Callow rougher cells. Each primary rougher cell, with its series of three single length cleaner cells, is a separate circuit and is supplied with air at from four to six pounds pressure by a Connersville blower, operated by a 50-H.P. motor. The tailing from the rougher cells receives a final concentration treatment before being sent to waste. In each system of cells, the concentrate from the rougher cells passes to a double compartment cleaner cell which discharges its concentrate to a tank. A diaphragm pump lifts it to a second cleaner cell which discharges its concentrate to a second tank. It is lifted to a third cleaner cell for final treatment, the cleaned concentrate from which now assays 600 ounces of silver to the ton. This is discharged to a 20 ft. by 10 ft. Dorr thickener, dewatered on an Oliver continuous filter, and dried for shipment. Sodium silicate, in the proportion of fifteen pounds per ton of final concentrate produced, is added to the cleaner cells as a deflocculant.

The Middling Circuit.—The tailings from the cleaner cells are known as the "middlings." The middling circuit is another separate unit. The system includes a double length (16 inch) double-compartment rougher cell, known as the middling cell, followed by two single length cleaner cells. The middlings flow to a sump, from which they are lifted by a 3-inch pump to the middlings rougher cell. The tailing from this cell joins the tailing from the three rougher cells for a final treatment by concentration. The concentrates from the middlings cell pass to the first cleaner cell. Sodium silicate is added to the concentrate from this cell, which is raised by an air-lift to the second cleaner cell, where it receives the final treatment. The tailing from the two cleaner cells is returned to the middling circuit. The cleaned concentrate flows to the Dorr thickener.

The Tailing Circuit.—The tailing from the four rougher cells goes to a box and is lifted by a 4-inch centrifugal pump to an 8-ft. Callow cone. The underflow passes over eight No. 2 Deister sand tables, the concentrates from which are cleaned on a finishing table. The tailing from these tables goes to waste. The overflow from the Callow cone goes to a treble-length double-compartment rougher cell, the tailing going to waste. The concentrate is cleaned in a 9-ft. double-compartment cleaner cell, the tailing from which is returned to the middling circuit. The concentrate is sent to the Dorr thickener.

The Coniagas practice, as described above, is shown in outline in the following flow-sheet:—

TABLE XXXVIII



Flotation flow-sheet of Coniagas practice.

The following chart, taken at random, for the month of April, 1923, shows the results obtained at this plant.

TABLE XXXIX.—MONTHLY CHART OF THE CONIAGAS FLOTATION PLANT, SHOWING MONTHLY AVERAGES, TOGETHER WITH SIZING ANALYSIS AND ASSAYS OF THE DAILY TAILING, FOR THE MONTH OF APRIL, 1923

Monthly average....	Flotation head..................	3.40 ounces
	Primary rougher tailing........	.79 "
	Final tailing..................	1.23 "

Date	Percentage of weight				Assay: ounces of silver per ton			
	80	100	150	150	80	100	150	150
1st.....	9.89	9.44	16.40	64.27	2.0	1.6	1.4	1.7
2nd.....	11.75	7.44	14.14	66.67	1.6	.8	.7	1.4
3rd.....	15.34	7.62	16.19	60.95	2.0	1.2	1.0	1.8
4th.....	12.29	9.31	15.62	62.78	2.2	2.0	1.8	3.4
5th.....	9.82	10.48	14.81	64.89	1.8	1.6	2.6	1.8
6th.....	7.45	6.69	12.92	72.94	2.6	1.5	1.1	2.0
7th.....	10.63	9.19	17.12	63.06	1.0	1.7	.8	1.8
8th.....	6.13	6.28	17.52	70.07	1.6	1.0	1.0	1.4
9th.....	4.50	6.74	15.73	73.03	1.4	1.2	1.3	2.0
10th.....	12.12	10.05	14.83	63.00	.8	.8	.6	1.0
11th.....	9.22	8.68	15.55	66.55	1.0	.6	.5	.9
12th.....	9.56	8.53	15.56	66.45	1.1	.7	.4	1.0
13th.....	9.47	8.63	17.26	64.62	.7	.6	.4	.9
14th.....	12.37	8.44	14.56	64.63	1.0	1.1	.7	1.8
15th.....	5.89	7.68	18.03	68.40	.9	.6	.5	1.2
16th.....	7.06	7.55	14.22	71.17	1.0	.7	.6	1.2
17th.....	10.50	8.78	14.89	65.83	1.2	1.1	1.1	2.5
18th.....	8.52	7.40	14.01	70.07	.9	.7	.6	1.2
19th.....	9.02	9.13	14.60	67.27	.5	.8	.5	1.0
20th.....	9.34	7.00	16.93	66.73	.8	.6	.4	1.0
21st.....	9.19	6.85	14.64	69.32	1.0	1.1	.7	1.4
22nd.....	11.51	10.75	15.80	61.94	.6	.6	.4	1.2
23rd.....	10.89	8.35	13.61	67.15	1.7	1.1	.6	1.7
24th.....	6.02	7.98	17.26	68.74	.9	.6	.5	1.1
25th.....	6.06	7.19	15.99	70.86	1.3	.6	.5	1.0
26th.....	8.05	7.26	17.94	66.75	.8	.6	.7	1.2
27th.....	7.57	8.38	16.16	67.89	.9	.6	.5	1.1
28th.....	11.70	7.02	14.82	66.46	.8	.9	.6	1.5
29th.....	9.38	11.69	15.23	63.70	1.1	.9	2.3	1.7
30th.....	9.88	7.49	14.65	67.98	1.0	.8	.8	1.6
Average..	9.37	8.26	15.57	66.80	1.21	.96	.85	1.48

NOTE:—The difference between the rougher tailing and the final tailing is due to middlings.

TABLE XXXIX*a*.—ANALYSIS OF FLOTATION CONCENTRATES, CONIAGAS MILL, FEB. 27, 1923
(Ag. 504.0 oz. ton, 1.7 per cent.)

	Per cent.
Insoluble	42.32
Pb..	.21
Cu..	3.55
Sb..	1.32
As..	5.98
Fe..	14.80
Al_2O_3	8.82
Ni..	.55
Co..	2.04
Zn..	.12
CaO...	5.23
MgO...	2.25
S...	8.35
Total........	95.54

Additional Notes

Flotation of Cyanide Tailings.—The flotation process has not been combined successfully with cyanidation treatment, as each interferes seriously with the other. This fact was brought out by the attempt of the Nipissing mines in 1916-1917, to treat the tailing from the low-grade mill by flotation.

Owing to the increased cost of aluminium, which advanced in 1915 from 19 cents to over $1.00 a pound, it was necessary to find a substitute for the desulphurizing treatment, in order to treat ores containing silver chemically combined with arsenic, antimony, and sulphur. On such ores, with a 48-hour treatment, straight cyanidation gave a poor extraction. The treatment of the cyanide tailing by flotation naturally suggested itself. Experiments to that end were conducted on a commercial scale for a period of over a year, but after trying many variations in the method of applying the treatment, the attempt was abandoned, as the results were not satisfactory. The low extraction of the precious metal was apparently due to the fact that the solvent action of the cyanide solution had pitted the surface of the base-metal particle containing the silver, so that it floated with difficulty. The flotation cells were discarded and the present practice was adopted, of gravity concentration on tables, followed by cyanidation. As already indicated, this practice has been found entirely satisfactory. Another factor in favour of gravity concentration in this plant was that it readily recovered the cobalt minerals in the ore. By the flotation treatment this valuable by-product for the most part was not recovered, as the arsenides are floated with difficulty.

The analyses of the flotation products from the Nipissing plant are shown in the following table:—

Table XL.—Analysis of Nipissing Flotation Products

Schedule	Heads	Tails	Concentrates
Silver, ounces	7.12	2.4	729.9
	Per cent.	Per cent	Per cent.
Silver	0.025	0.008	2.50
Copper	Trace	Trace	2.70
Cobalt	0.17	0.16	0.21
Nickel	0.11	0.10	0.14
Arsenic	0.70	0.66	0.85
Sulphur	0.32	0.10	3.69
Insoluble	71.52	71.31	54.28
Iron and Aluminium	16.72	16.76	20.93
Lime	3.56	3.64	3.04
Magnesia	1.10	1.00	0.98
Volatile, H_2O, CO_2, etc.	5.20	5.20	8.30
	99.425	98.938	97.62

The copper was paid for on the basis of five cents per pound.

Local Treatment of Concentrates.—A most serious objection to the flotation process is the difficulty of treating the concentrates to recover the silver as a fine bullion. Owing to the excessive marketing charges, the metallurgists of the district, and elsewhere, have experimented with practically every well-known process, in addition to carrying on a considerable amount of original research, in the effort to devise a satisfactory method of treatment. Fine grinding with straight cyanidation, and wet desulphurization followed by cyanidation have both failed. The principal difficulty is the excessive cyanide consumption (over 75 lbs. per ton of concentrates) which is due to the presence of large amounts of iron and copper mineral, as well as other base-metals, that act as cyanicides.

It was thought by some metallurgists that a chloridizing roast in the Holt-Dern furnace, followed by an acid-salt leach, might solve the problem. To try out this process, experiments were carried on at the Buffalo mines and the Dominion Reduction Company, the former installing a large furnace of this type and the latter four small ones. In both cases, after operating for several months, the process was abandoned, as it was not a success either commercially or metallurgically. On account of the fineness of the product, it was found impossible to get any large tonnage through the furnace. Furthermore, the product did not leach well, so that the extraction did not exceed 92 per cent. A still further disadvantage was the fact that the bullion recovered always contained a considerable amount of copper, which necessitated paying a refining charge.

All the flotation concentrates from the camp are shipped to smelters in the United States. Payment is made for the copper as well as the silver content.

The Cost of Marketing Concentrates.—The cost of marketing concentrates from the flotation process is shown in the following schedule. This brings out very clearly the marked advantage of shipping a high-grade rather than a low-grade product.

TABLE XLI.—COMPARATIVE RETURNS FROM DIFFERENT GRADES OF FLOTATION CONCENTRATES.

GENERAL:—

Freight Cobalt to smelter, per ton	$24.40
Smelter treatment charge, per ton	14.00
Smelter refining charge, per ounce	.00¼
Smelter percentage	5%
Representation and assaying, per ton	$0.86
Estimated price of silver, per ounce	.65

100 OUNCE CONCENTRATE:—

Freight	$24.40	Value	$65.00
Treatment	14.00	Less	42.76
Refining	.25		
Percentage	3.25	Net	$22.24
Representation and assaying	.86		
	$42.76		
Percentage of total value of ore received			34.21

200 OUNCE CONCENTRATE:—

Freight	$24.40	Value	$130.00
Treatment	14.00	Less	46.26
Refining	.50		
Percentage	6.50	Net	$83.74
Representation and assaying	.86		
	$46.26		
Percentage of total value of ore received			64.41

300 OUNCE CONCENTRATE:—

Freight	$24.40	Value	$195.00
Treatment	14.00	Less	49.76
Refining	.75		
Percentage	9.75	Net	$145.24
Representation and assaying	.86		
	$49.76		
Percentage of total value of ore received			74.48

400 Ounce Concentrate:—

Freight	$24.40	Value	$260.00
Treatment	14.00	Less	53.26
Refining	1.00		
Percentage	13.00	Net	$206.74
Representation and assaying	.86		
	$53.26		

Percentage of total value of ore received 79.51

500 Ounce Concentrate:—

Freight	$24.40	Value	$325.00
Treatment	14.00	Less	56.76
Refining	1.25		
Percentage	16.25	Net	$268.24
Representation and assaying	.86		
	$56.76		

Percentage of total value of ore received 82.53

600 Ounce Concentrate:—

Freight	$24.40	Value	$390.00
Treatment	14.00	Less	60.26
Refining	1.50		
Percentage	19.50	Net	$329.74
Representation and assaying	.86		
	$60.26		

Percentage of total value of ore received 84.55

TREATMENT OF HIGH-GRADE ORE

Introduction

In the early days of the Cobalt camp the high-grade ore, together with the concentrates from the jigs and tables, was shipped to smelters in the United States for treatment. Later, special plants for treating these ores were built at Deloro, Thorold, Copper Cliff, and elsewhere. Owing to the complex nature of the ore, and the high arsenic content, this material was difficult to treat, and undesirable for the ordinary customs smelter. The general practice was to smelt in blast furnaces, recovering most of the silver as a base bullion. The resulting speiss was roasted and treated by wet methods for the recovery of the remainder of the silver, together with the cobalt and nickel. The arsenic trioxide from the roasting was recovered in bag-houses. The process was slow and required a large working capital as well as a heavy expenditure for plant.

In view of marketing difficulties, the management of the Nipissing, as early as 1908, undertook to investigate the possibility of treating the ore locally. A test plant was built, and a series of experiments carried out, with a view to developing a process by which the ore could be treated at the mine. It was desired that the process be at once efficient, inexpensive, simple to operate, one that did not require an expensive plant and that would produce the silver in a form ready to market as fine bullion. These experiments were finally successful and resulted in the building of the Nipissing high-grade mill, which began to operate in February, 1911.

Amalgamation and Cyanidation

The Nipissing High-Grade Mill

The process used at the high-grade mill, as developed by Chas. Butters and G. H. Clevenger, consisted of tube-mill amalgamation followed by cyanidation. In this plant only hand-sorted ore and jig concentrates were treated, as table concentration was not used at the Nipissing during this period. The process is fully described by R. B. Watson ("The Nipissing High-grade Mill," *Engineering and Mining Journal*, Dec. 7th, 1912). A brief outline of the process, based on Watson's article, is as follows:—

Sampling.—The high-grade ore was put through a 9 by 15 Blake crusher and fed to a No. 3 6-ft. Krupp ball-mill, carrying 1,000 lbs. of steel balls, and fitted with 20-mesh screens. The metallics were removed periodically from the ball-mill, and melted down in the refinery. The pulp from the ball-mill was delivered to a Vezin sampler and elevated to steel storage tanks.

Amalgamation.—The main operation consisted of amalgamating the silver in a tube-mill, by grinding the ore with mercury in 5 per cent. cyanide solution. For this purpose a Krupp mill was used, fitted with Silex liners and turning at 37 r.p.m. About one pound of mercury was used for every ounce of silver present, the ordinary charge being 6,500 lbs. of 2,500-ounce ore, 8,500 lbs. of mercury, 3,800 lbs. of 5 per cent. KCN solution, and six tons of pebbles. The mill was revolved for nine and a half hours, when 99 per cent. of the pulp would pass a 200-mesh screen, and the amalgamation was complete. By means of a special arrangement, compressed air was blown through the tube-mill to keep down the temperature, and to enable the cyanide to dissolve a greater proportion of the silver.

The charge was then dumped into an 8-ft. all-iron settler, fitted with wooden shoes. The amalgam was finally drawn off into canvas bags where it was allowed to drain, after which it still carried 78 per cent. of mercury. The pulp was discharged to the agitation tank for further treatment. The remarkable part about the whole process is that 97 to 98 per cent. of the total silver in the ore yielded to amalgamation in the tube-mill. Ore assaying 2,500 ounces to the ton was reduced to from 50 to 75 ounces when it left the settler.

Cyanidation.—The subsequent cyanidation of the pulp was relatively unimportant, as it dealt with the daily treatment of only six or seven tons of 50-ounce ore. A charge for agitation was made up of four tube-mill charges, or thirteen tons of dry pulp. Five pounds of lime were added per ton of pulp, and the charge agitated for thirty-six hours in 0.75 KCN solution in mechanically agitated tanks. After settling and decanting, the pulp was filtered on a Butters filter, and the clarified solution precipitated by passing through zinc-boxes filled with coarse zinc shavings. The residue left on the filter was stored. It contained thirty-five ounces of silver and fifteen to twenty pounds of mercury to the ton. This material has since become valuable for its cobalt content. An analysis of the residue is as follows:—

TABLE XLII.—ANALYSIS OF RESIDUE FROM AMALGAMATION—CYANIDATION OF HIGH-GRADE ORE

Silver	35	Oz. Ton.	Arsenic	29.50	per cent
Nickel	9.72	per cent.	Sulphur	1.59	"
Cobalt	5.85	"	Silica	11.44	"
Iron	2.58	"	Lime	8.63	"
Antimony	3.80	"	Magnesia	2.91	"
Bismuth	0.09	"	Mercury	1.00	"
Copper	0.06	"	Alkali Gold Oxygen		Trace
Carbonic acid	13.55	"			
Combined water	5.74	"			
			Sn., Zn., Mn	3.15	per cent.

Determinations of the mercury consumption brought out the interesting fact, until then unsuspected, that the high-grade ore itself contained mercury, to the amount of two to five pounds per ton of ore. This was found to be contained in the metallics.

Retorting.—After draining in the sacks the amalgam was sent to the refinery, where it was weighed and charged into six 14 by 60-in. oil-fired retorts, arranged in batteries of two. The retorts were charged three-quarters full. They were fired for nine hours, and, after being allowed to cool for six hours, were then opened, and the resulting sponge weighed. The sponge assayed approximately 80 per cent. silver, the main impurities being arsenic, cobalt, nickel, antimony, and bismuth.

Refining.—The sponge from the retorts, in charges containing 28,000 ounces of silver, was melted down in an oil-fired reverberatory furnace. At first the furnace was lined with ordinary acid fire-brick, but later, magnesite brick was substituted to advantage. Air at fifteen pounds pressure was blown on the surface of the molten charge, from two iron pipes at the back of the furnaces. The oxides of cobalt, nickel, and other impurities rose rapidly to the surface, and were raked off through the charging door. No flux of any kind was required. The blowing was continued until the bullion was 999 fine, as determined by dip samples. It was then tapped into moulds.

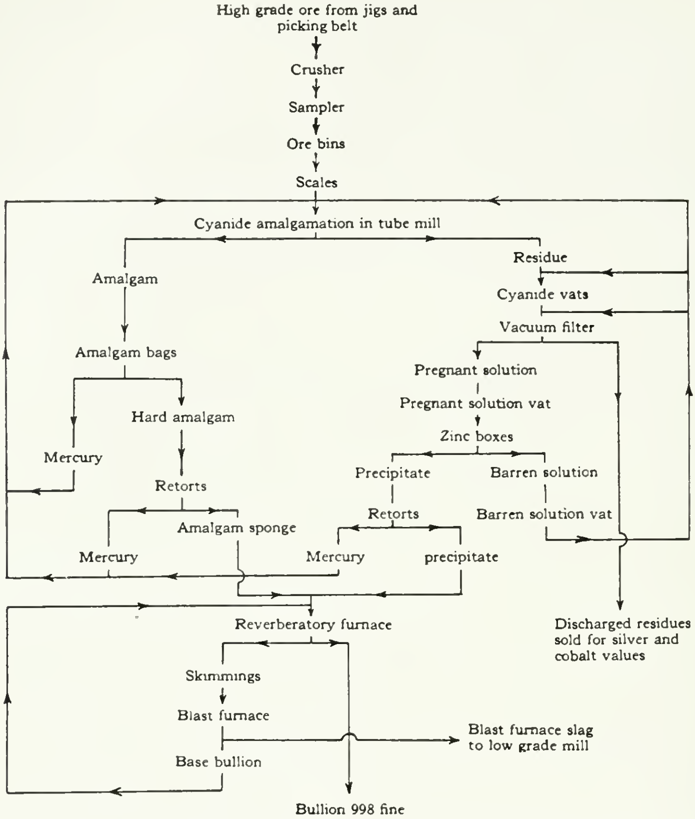
The waste gases were passed through dust chambers, to recover the mercury in the fumes. These consisted of brick chambers and two iron pipes 3 ft. by 27 ft., connected by brick work. The pipes were sprayed externally and at intervals sprays were introduced into the first pipe and the last chamber. Practically the whole recovery, amounting to 1,000 lbs. to 2,000 lbs. of mercury per month, was in the pipes, mostly in the first one, which was provided with the internal sprays.

Smelting.—A 20-in. round, water-jacketed blast furnace was installed to smelt the skimmings from the melting furnace, together with the flue dust, and the zinc precipitate from the cyanide plant. The flue from the furnace was connected with the dust chambers. Before being charged to the blast furnace, the flue dust and precipitate were retorted, then mixed with sugar-water, briquetted, and dried.

The skimmings assayed about 15,000 ounces, the flue dust 700 ounces, and the precipitate 15,000 to 18,000 ounces of silver to the ton. The charge was so rich in silver that no lead was necessary. The products were a base bullion, about 800 fine, which was melted down in the reverberatory furnace, and a slag carrying from five to eleven ounces of silver to the ton. A small amount of speiss was also formed. It was necessary to run the blast furnace only one day in ten, to clean up all the by-products.

Recovery and Costs.—The treatment, as outlined above, was remarkably efficient and expeditious, the silver being delivered as fine bullion, at New York, within a week of the day that the ore was delivered to the mill. Based on uncorrected fire assays, the recovery was as high as 99.5 to 100 per cent. Of this total, 95 to 96 per cent. was recovered by amalgamation, and 5 to 4 per cent. by cyanidation. The total cost of the plant was $67,757.00, which includes the sampler, mill, and refinery.

TABLE XLIII



Flow-sheet of Nipissing high-grade mill. Tube mill amalgamation, 1911-1918.

Additional Notes on Amalgamation

Retorting.—The retorts were required to withstand hard and continuous service, and for this purpose retorts of cast iron proved to be unsatisfactory. Various grades of iron were tried, but all were found liable to crack, owing to the high temperature and the weight of the sponge. A soft grey iron, low in phosphorus, was found to give the best results. The average life of a retort was thirty-four charges, though occasionally a retort would break on the first firing. Later, retorts of cast steel and wrought iron were tried with better results.

A system of retorting using graphite crucibles was finally installed, and proved to be very satisfactory. A desirable feature of this system was that in one operation it permitted the retorting of the mercury and the melting down of the resulting silver sponge. It had the additional advantage of being cheaper and simpler to operate, and of requiring less fuel oil. A crucible was good for thirty-five melts.

In operation, about 1,200 lbs. of amalgam were charged into a No. 400 Morgan graphite crucible. After fastening down the cover, which was connected to the condensing pipe, the crucible was fired for a period of five hours, the heat being gradually increased up to the melting-point of silver. The tops were then removed and the silver cast into bars of base bullion. Using this system of retorting, the mercury content of the base bullion was reduced to less than one per cent.

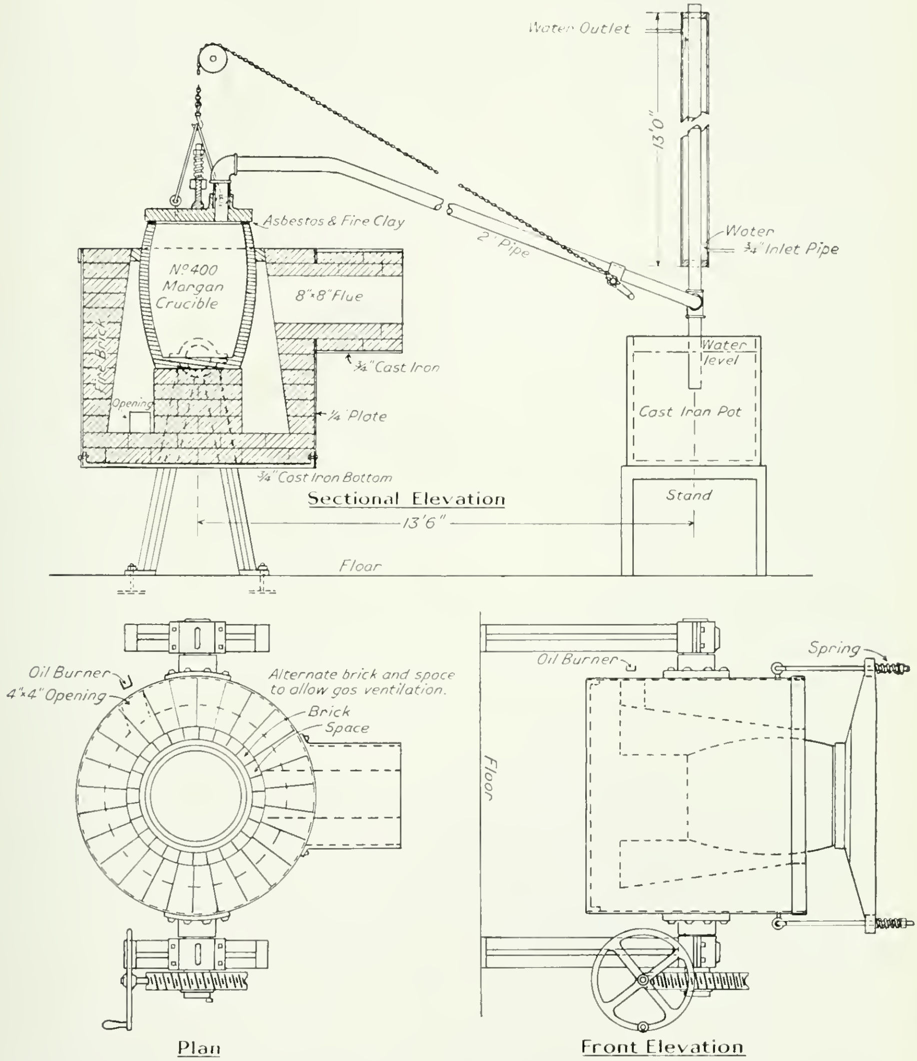


Fig. 67—Tilting retort, Nipissing Mining Company.

Mercury Content of Silver Sponge and Base Bullion.—On retorting the amalgam in iron retorts, the silver was left as a sponge bar 4 ft. by 10 in. by 6 in., which weighed about 900 lbs. The crucible system yielded a bar of base bullion. "Saw-cut" samples of these, made by sawing clean through the bar at the centre, and at both ends, were then assayed for mercury. It was found that the mercury content of the solid portion of the sponge bar was always less than that of the porous portion; that usually it was lower at the centre than at the ends; and that it was less in the bar of base bullion than in the sponge bar. These facts are brought out in the following tables which show the analyses of a number of bars of both types.

Table XLIV.—Distribution of Mercury in Sponge and Base Bullion Bars

Mercury content in sponge bar after retorting in iron retorts		Mercury content of bar of base bullion, after retorting and melting in crucibles and pouring into moulds	
Bar "A"—			
Solid end	1.75 per cent. Hg.		
Solid centre	1.62 "		
Porous end	3.14 "		
Bar "B"—		Bar "E"—	
Porous end	11.45 "	End	0.94 per cent. Hg.
Solid centre	1.91 "	Centre	0.86 "
Solid end	1.69 "	End	1.11 "
Bar "C"—		Bar "F"—	
This was half solid		End	1.07 "
and half porous.		Centre	0.94 "
End	2.46 "	End	0.98 "
Centre	2.58 "		
End	1.13 "	Bar "G"—	
Bar "D"—		End	1.24 "
This was porous throughout		Centre	1.01 "
End	3.28 "	End	1.02 "
Centre	2.29 "		
End	2.58 "		

Mercury Losses in the Residues.—The mercury lost in the residues was in the form either of floured mercury or of the sulphide HgS. As already noted, this amounted to fifteen to twenty pounds per ton. At the Nipissing high-grade mill, various attempts made to recover the lost mercury were not successful. For the most part the mercury was present in the residue in a finely divided metallic state, with only a small amount of the sulphide. This was due to the fact that, at the Nipissing mill, only clean high-grade ore and jig concentrates were treated, and this material was low in sulphur. This is shown in the following table:—

Table XLV.—Sulphur Content of Clean High-Grade Ore From Various Mines, Sampled in Lots of Approximately 30 Tons.

Nipissing—average of	9 lots	2.98 per cent.
La Rose "	6 "	1.72 "
Kerr Lake. "	5 "	1.16 "
Cobalt Comet "	3 "	1.53 "
Crown Reserve "	2 "	1.16 "

Table concentrates, on the other hand, contain from 4 per cent. to 7 per cent. of sulphur, and the treatment of this material causes an excessive loss of mercury in the residue, most of it being in the form of the sulphide. This was the cause of the high mercury losses at the Buffalo high-grade mill which was built in 1912 to treat the jig and table concentrates. The practice used was essentially the same as developed at the Nipissing, except that, in places, the same object was accomplished by the use of a different type of machine.

The Thornhill Process.—A process to recover the mercury from the current and accumulated residues was developed in 1914 at the Buffalo plant, and is described by E. B. Thornhill, metallurgist for the company[1]. The process, successfully introduced by Mr. Thornhill, consisted essentially of leaching the mercuric sulphide from the residues by means of a caustic alkaline solution of sodium sulphide, and precipitating the mercury with metallic aluminium. The reactions involved are shown in the following equations:—

(1) $HgS. + Na_2S = HgS. Na_2S.$

(2) $3HgS. Na_2S + 8\ NaOH + 2Al = 3\ Hg + 6\ Na_2S + Na_2\ Al_2O_4 + 4\ H_2O.$

Since the dissolution of the mercuric sulphide is very rapid, no agitation was required, the solvent being applied to the residue on the filter leaf.

In practice, the pulp was caked on a Moore filter, and washed with water until free of silver solution. Sodium sulphide solution was then drawn through the cake, until the effluent solution showed only a trace of mercury. The strength of the solvent was kept up to 4 per cent. Na_2S and 1 per cent. NaOH. Usually one ton of solution per ton of residue was sufficient. The mercury was precipitated by agitating the mercuric sulphide solution with granular aluminium. After settling and decanting, the mercury was run off and strained through canvas.

The cost of treatment for labour and chemicals is given as thirteen cents per pound of mercury recovered. An interesting point is that the mercury recovered is very pure, and is absolutely free of arsenic.

The Buffalo practice, together with the sodium sulphide treatment of the residues, is shown in outline in the following flow-sheet of the Buffalo high-grade mill.

Losses of Mercury in the Stack.—A considerable amount of research work has been done at the Nipissing high-grade mill, to improve the recovery of values contained in the waste gases from the refining and smelting furnaces.

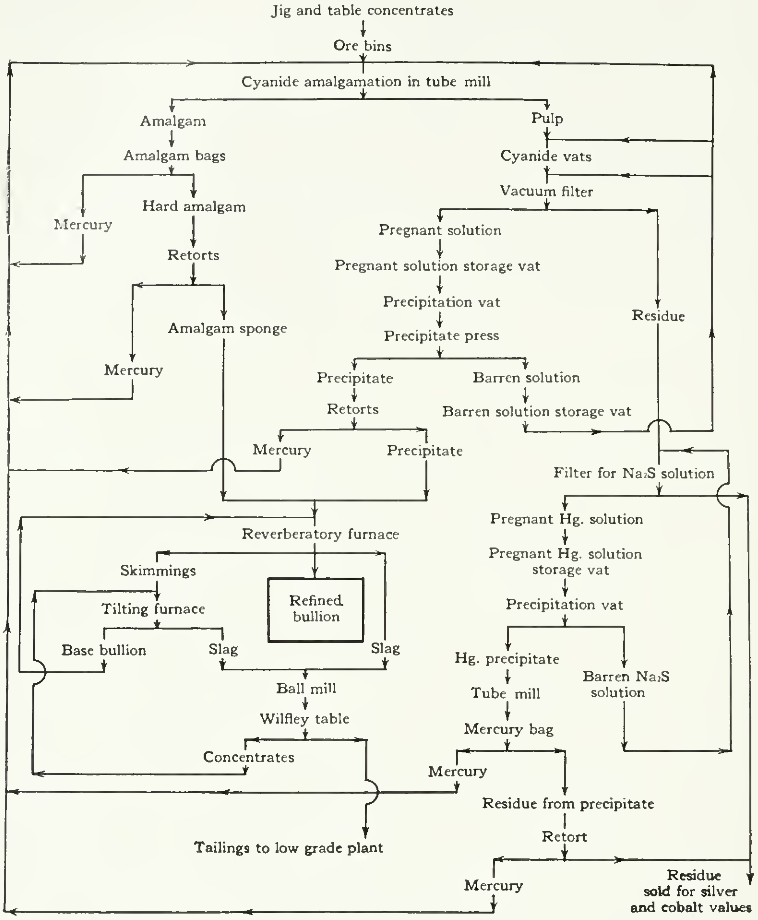
The original installation of brick chambers and water-sprayed iron pipes, to recover the dust and fumes from the waste gases, has already been described. Later improvements included the substitution of the crucible system of retorting, in place of the cast-iron retorts, which reduced the mercury content of the amalgam sponge to less than 1 per cent., and the addition of a bag-house to improve the recovery of fume.

The bag-house was 18 ft. 8 in. by 18 ft. 8 in. by 22 ft. 9 in., and contained forty-two woollen bags, each 20 in. by 22 ft. The gases were drawn through the older arrangement of dust chambers and passed through the bags, where a further recovery of the fume was made. The bulk of the material collected in the bag-house consisted of arsenic, antimony, nickel, cobalt, and bismuth, together with mercury and silver. The amount was surprisingly small, considering the nature of the material treated, and the volatile constituents that it contained. After starting the new high-grade treatment, no precipitate was

---

[1] "Recovery of Mercury from Residues of Amalgamated Cobalt Ores," A.I.M.E. Trans., Vol. LII., 1915, p. 165; C.M.I. Trans., Vol. XLVI, 1915, p. 94.

TABLE XLVI



Flow-sheet of high-grade and mercury extraction plant, Buffalo Mines, Ltd.

found in the bags after a run of several months, and the bag-house practice was then discontinued. A stack 105 feet high was built at the end of the last dust chamber, to supply the draft in place of the fan.

Tests on Cottrell Process.—In January, 1915, tests were made with the Cottrell system for the precipitation of fumes on a portion of the gases before entering the bag-house. The volume of the stack gases was calculated from readings from a standard Pitot tube, and an Ellison differential draft gauge. Care was taken in every test to maintain the average reading in the sampling tube the same as in the stack.

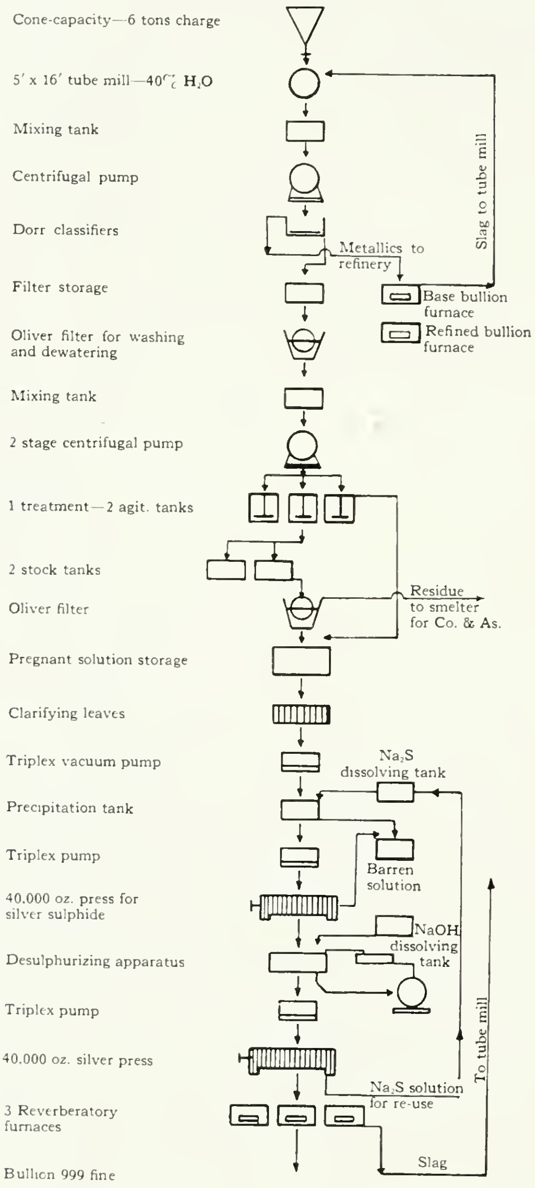
The results of these tests indicate that 90 per cent. of the dust carried by the total gases could be collected by the Cottrell system of fume precipitation. The Cottrell system was not installed, as the value of the increased amount of dust collected did not warrant the expense of changing over, particularly when the crucible system of retorting was developed at this period.

The results of some tests with the Cottrell system of fume precipitation are given in the following table:—

TABLE XLVII.—TEST ON PRECIPITATING DUST FROM REVERBERATORY FURNACES, BLAST FURNACE, AND RETORT GASES, BY THE COTTRELL SYSTEM OF PRECIPITATION OF FUMES

Test No.	Furnaces in operation	Furnace charge	Duration of test	Voltage on electrode	Electrode used	Temperature of gases	Velocity of gas per sec.	Total volume of gas through flue during test, cu. feet	Volume of gas treated cu. feet	Percentage of total gas treated	Weight of dust precipitated, lbs.	Dust that should be precipitated from total volume, lbs.	Assay of silver, ozs. per ton	Assay of mercury, bs. per ton
1	H.G. reverberatory L.G. “ Blast furnace...... Retorts...........	1,500 lbs. base bullion, 1,150 lbs. amalgam sponge 20,000 oz. L.G. ppts. 15,000 oz. base-bullion 700 lbs. H.G. skimmings 1,222 lbs. mill clean-up 1,588 lbs. Nip. nuggets	10 hrs.	40,000	single No. 18 iron wire	24° C.	7.36	6,726,000	136,440	2.28	0.922	97.1	854.0	179.1
2	H.G. reverberatory Blast furnace......	1,500 lbs. base bullion 3,450 lbs amalgam sponge Wood, rags and scrap Low-grade skimmings	48 hrs.	40,000	single ⅛-in. gas pipe	17° C.	6.58	31,624,000	570,240	1.80	0.797	22.2	222.0	416.9
3	H.G. reverberatory Blast furnace...... Retorts...........	2,000 lbs. amalgam sponge mill clean-up pan clean-up	24 hrs.	40,000	⅛-in. gas pipe and 6 No. 18 iron wires	7° C.	8.35	15,220,000	393,120	2.58	0.468	18.1	380.0	56.0
4	H.G. reverberatory Retorts...........	2,400 lbs. amalgam sponge pan clean-up	17 hrs.	40,000	⅛-in. gas pipe and 6 No. 18 iron wires	17° C.	5.44	11,200,000	256,037	2.28	0.234	14.3	245.0	180.3
5	H.G. reverberatory Retorts...........	2,100 lbs. H.G. ppts...... pan clean-up	15 hrs.	40,000	single No. 18 iron wire	18° C.	3.71	9,882,000	109,000	1.10	0.266	39.0	403.0	138.6

TABLE XLVIIa



Cobalt Reduction Company, flow-sheet of high-grade plant treating 2000-3000 ounce ore.

Cyanidation

The amalgamation-cyanidation process, as described above, was used at the Nipissing mill for the treatment of high-grade ore and jig concentrates for a period of seven years, during which time it gave satisfactory results. The circumstances that led to the abandonment of amalgamation in 1918 were the result partly of economic disturbances caused by the war and partly of changes in the ore and in marketing conditions. The amalgamation process in operation required the use of large stocks of mercury as a working medium. During the war, the price of mercury advanced from $33 to $130 per flask of seventy-five pounds, and the inevitable losses of mercury in the residues and fumes, amounting to twenty-four pounds per ton of ore, became a serious matter. In addition to this, the character of the material to be treated had changed. As already outlined in the discussion of the treatment of low-grade ore, the low-grade mill, after experimenting with flotation, in 1918 adopted gravity concentration before cyaniding, and the high-grade mill was now required to treat the concentrates from the table and a less amount of high-grade ore. As the experience of the Buffalo mill had already shown, table concentrates are not amenable to the amalgamation process, owing to their high sulphur content and the presence of other impurities, which cause a heavy loss of mercury in the residues. For these reasons, the Nipissing management in 1918 decided to discontinue amalgamation, and adopted instead the hypochlorite cyanidation process which had already been developed, and was then in successful operation, at the Cobalt Reduction plant.

The problem of recovering the silver from high-grade ores and concentrates by cyanidation alone, without amalgamation, had long engaged the attention of the Cobalt metallurgists. As already pointed out in the discussion on the nature of the ore, the ordinary treatment of this material with cyanide gave disappointing results; the cyanide consumption was very high, and the extraction of silver was low. The high consumption of cyanide was due to the various cyanicides present, of which nickel was by far the worst offender. The low extraction was due to the presence of antimonial silver and various reducing compounds which interfered with dissolution. By continued research work, it was finally shown that a high extraction could be made with a normal cyanide consumption, if the ore was ground very fine to assist dissolution and given a preliminary treatment for the removal or oxidation of the base-metal compounds. The preliminary treatment oxidizes these compounds that would otherwise act as reducing agents, leaving the silver readily amenable to cyanidation. It has but little effect on the cobalt and nickel arsenides, which remain unaltered.

Two different preliminary treatments have been developed, the hypochlorite treatment and the acid wash. These will now be described briefly:—

The Hypochlorite Treatment

This process, developed in 1915 at the plant of the Cobalt Reduction Company, is still in operation. At the Nipissing it was substituted in 1918 for the older amalgamation-cyanidation process, and continued to be used until the development of the acid wash treatment in 1921. The practice used at the Cobalt Reduction and Nipissing mills is almost identical except for the present difference in the preliminary treatment.

Cobalt Reduction Company Practice

Sampling.—The wet concentrate from the low-grade treatment is mixed thoroughly and sampled by coning and quartering. Duplicate samples are taken and assayed for moisture and silver. A composite sample is made up every month and assayed for cobalt and nickel. When the work is done carefully, this system of sampling is found to check with the silver recovered as bullion.

Grinding and Hypochlorite Treatment.—Five to seven tons of high-grade ore or table concentrates (4 mesh) are charged into a 5 ft. by 16 ft. tube-mill, loaded with 2-inch iron balls, and ground for eighteen hours with a dilution of 1:1. Calcium hypochlorite is then added at the rate of fifty to seventy-five pounds per ton of ore treated, depending upon the amount of sulphides present, and the grinding is continued for an additional six hours. The pulp is then discharged and fed to a Dorr classifier, to separate the coarse metallic silver from the slime pulp. The metallic silver discharged from the classifier is recharged to the tube-mill with the next lot of ore, for further grinding. The slime overflow from the Dorr classifier, containing about 1 per cent. of plus 200-mesh sand, passes to a tank where it is settled and decanted to give a thickened pulp, having a dilution of 1:1. It is then discharged to an Oliver continuous filter, where the pulp is washed free of soluble chlorides.

Agitation.—Owing to the solubility of nickel arsenide in cyanide solution, and the effect which it has of re-precipitating the dissolved silver, it is imperative to get a rapid dissolution of the silver, and when once this is accomplished, to separate the pregnant solution from the ore as quickly as possible. This will result in the saving of considerable cyanide, and prevent the re-precipitation of the silver into the residues. Rapid dissolution of the silver is effected by treating the ore with a solution high in cyanide, at a high dilution, and by circulating the pulp with a 7-inch centrifugal pump, in order to aerate it thoroughly. In practice, washed cake from the filter discharges to a 20 ft. by 10 ft. mechanically agitated treatment-tank. The charge is made up to a dilution of 25:1, and the cyanide strength kept up to 0.5 per cent. The pulp is then thoroughly agitated and aerated for fourteen hours, after which it is allowed to settle for five hours and the excess solution decanted. The cyanide strength must not be allowed to fall below 0.2 per cent. KCN, as re-precipitation of the dissolved silver will then take place. The pulp is again agitated, and pumped to the stock tank for filtering.

Precipitation and Refining.—The precipitation of the silver with sodium sulphide and the subsequent desulphurizing and refining of the precipitate are identical with the Nipissing practice already described.

Recovery.—The treatment described gives a recovery of 97 per cent. of the silver contained in the high-grade ore and table concentrates, in a ninety-six-hour treatment.

Residues.—The residue discharged from the filter contains from fifty to seventy-five ounces of silver to the ton. The average analysis of this material, which is sold to the smelters for its silver and cobalt values, is as follows:—

TABLE XLVIII.—ANALYSIS OF RESIDUE FROM HYPOCHLORITE-CYANIDATION TREATMENT OF HIGH-GRADE ORE AND CONCENTRATES AT COBALT REDUCTION COMPANY

Arsenic	40.87	per cent.
Insoluble	8.24	"
Mercury	0.075	"
Copper	0.243	"
Sulphur	4.97	"
Lime	3.12	"
Iron	8.90	"
Cobalt	7.99	"
Nickel	7.68	"

The Acid-Wash Treatment

The preliminary acid-wash treatment replaced the hypochlorite treatment at the Nipissing high-grade mill in 1921. The Nipissing ores contain a greater amount of decomposed nickel compounds than do most ores in the district, and on this material the acid-wash treatment shows a greater saving in cyanide consumption than the older treatment with hypochlorite. The Nipissing practice is identical with that of the Cobalt Reduction in many respects. Only the more important differences are referred to here.

The sampling and grinding is identical with the Cobalt Reduction practice.

The ore is ground for twenty-three hours in charges of seven tons, in a 4 ft. by 25 ft. tube-mill under the conditions already described, and after settling and decantation in a tank, the 200-mesh pulp, with a dilution of 1:1, is pumped to a 20-foot by 10-foot wooden agitator tank, to receive the preliminary acid wash.

Acid Treatment.—The pulp is agitated for twelve hours with a 3 per cent. solution of sulphuric acid, the dilution being approximately 2:1. At the end of this period the acid strength is reduced to about 1 per cent., depending upon the amount of calcite in the ore. The dilution is raised to 12:1, and the pulp allowed to settle. The clear solution is then decanted and the washing operation repeated, to ensure the complete elimination of all soluble cyanicides. The thickened pulp is then agitated at a dilution of less than 1:1, and lime is added to neutralize the acidity, before discharging to the cyanide tanks. No attempt is made to filter at this stage, as any surplus solution made in the high-grade circuit, from incomplete dewatering of the pulp, is transferred to the low-grade circuit.

Cyanide Treatment.—The pulp from the acid treatment is pumped to the cyanide vats, where it is agitated mechanically, and circulated at the same time with a 7-inch centrifugal pump for a period of eight to twelve hours. The dilution is about 35:1. Starting with 0.5 per cent., the cyanide strength is not allowed to fall below 0.25 per cent., in order to prevent re-precipitation of the silver. After filtering, the silver is precipitated with sodium sulphide, and the precipitate desulphurized and refined in the manner already described.

Recovery.—The treatment as outlined above gives a recovery of 98 per cent. of the silver in the ores and concentrates. The discharged residue carries from thirty to sixty ounces of silver to the ton.

Residue.—The residue from the treatment is stored and sold to the smelters. Payment is made for the silver and cobalt values. The composition of the residue is shown in the following table:—

TABLE XLIX.—ANALYSIS OF RESIDUE FROM ACID-WASH CYANIDATION TREATMENT AT NIPISSING HIGH-GRADE MILL

Cobalt (Co)	7.31	per cent.
Nickel (Ni)	10.35	"
Arsenic (As)	33.79	"
Antimony (Sb)	2.16	"
Silver (Ag)	.24	"
Copper	Trace	"
Silica (SiO)	6.24	"
Alumina (Al_2O_3)	2.20	"
Iron (FeO—some Fe)	9.64	"
Lime (CaO)	10.26	"
Magnesia (MgO)	1.22	"
Sulphur (S—mostly SO_3)	4.17	"
Carbon Dioxide (CO_2)	7.78	"
	95.54	"
Soluble in H_2O (alkali carbonate, sulphates, chlorides, etc.)	6.42	"
Sulphate sol. in H_2O (SO_3)	.42	"

Treatment of Flotation Concentrates.—The various processes described above give excellent results when applied to the treatment of high-grade ore and jig and table concentrates. On flotation concentrates, on the other hand, the results are unsatisfactory. This is due to the fact that flotation concentrates are low-grade and carry large amounts of base-metal impurities that destroy cyanide. The film of oil surrounding the particles serves also to protect the silver from the dissolving action of the cyanide solution. The treatment of flotation concentrates has already been discussed (see under treatment of low-grade ore flotation), and will not be referred to further here.

BIBLIOGRAPHY OF MILLING PRACTICE AT COBALT

1906.—Robertson, John J.
"Cyanide tests on Temiskaming Ores,"
Can. Min. Inst. Transactions, Vol. IX, 1906, pp. 396 et seq.

1907.—Howe, Henry M.
Campbell, Wm.
Knight, Cyril W.
"Roasting of the Argentiferous Cobalt-Nickel Arsenides of Temiskaming, Ont , Canada,"
Transactions Am. Inst. Min. Engineers, 1907, Vol. XXXVIII, pp. 162-170.
Editorial Eng. and Min. Journal,
"Milling at Cobalt,"
Oct. 12, 1907, p. 698.
Hixon, Hiram W.
"Method of Smelting Cobalt Ores,"
Eng. and Min. Journal, March 2, 1907, pp. 426-427.
"The Smelting of Cobalt Ores,"
Can. Min. Inst. Transactions, Vol. X, 1907, pp. 74-76.

1908.—Flynn, F. N.
"Metallurgical Conditions at Cobalt, Ontario,"
Can. Min. Inst. Transactions, Vol. XI, 1908, pp. 292-334.
Min. and Sci. Press, Sept. 26, 1908, pp. 432-434.
Sancton, G. E.
"Methods of Concentration at Cobalt, Ontario,"
Can. Min. Inst. Transactions, Vol. XI, 1908, pp. 340-347.
Gillespie, Geo. H.
"Concentrating Cobalt Ores,"
Can. Min. Journal, April 1, 1908, pp. 103-106.

1911.—Young, H. G.
"Concentration at Hudson Bay Mines, Ltd.,"
Can. Min. Journal, Nov. 15, 1911, pp. 722-725.
Reid, Fraser D.
"Ore Dressing, Coniagas Concentrator,"
Can. Min. Journal, Jan. 1, 1911, pp. 23-24.
Pugsley, F. W.
"Sampling Ores from Cobalt Mines,"
Eng. and Min. Journal, April 15, 1911, p. 770.
Campbell & Deyell.
"Sampling of High-Grade Cobalt Silver Ores,"
Can. Min. Journal, Oct 15, 1911, pp. 660-663.
Globe, A. P.
"Concentrating Methods at the McKinley-Darragh Mine, Cobalt, Ontario,"
Can. Min. Journal, July 15, 1911, pp. 438-440.

1912.—Dobbins, W. J.
Anderson, H. G. S.
"Buffalo Mine and Mill, Cobalt."
Eng. and Min. Journal, Aug. 3, 1912, pp. 211-220.
Megraw, Herbert A.
"Cyanidation in the Cobalt District,"
Eng. and Min. Journal, Nov. 2, 1912, pp. 837-841.

WATSON, R. B.
"Nipissing High-grade Mill, Cobalt,"
Eng. and Min. Journal, Dec. 7, 1912, pp. 1077-1080.

1913.—MEGRAW, HERBERT A.
"The Cyanide Process in Canada,"
Can. Min. Inst. Transactions, Vol. XVI, 1913, pp. 146-151.
Can. Min. Journal, April, 1913, pp. 210-211.

1912.—MEGRAW, HERBERT A.
"Nipissing High-grade Mill, Cobalt,"
Eng. and Min. Journal, Dec. 14, 1912, pp. 1127-1128.

1913.—REID, FRASER D.
"Milling Practice in the Cobalt Camp,"
Can. Min. Journal, Sept. 1, 1913, pp. 542-543.
HORE, R. E.
"Amalgamation and Cyanidation of Cobalt Silver Ores,"
Can. Min. Journal, Sept. 15, 1913, pp. 568-572.
DENNY, JAS. J.
"Desulphurizing Silver Ores at Cobalt,"
Can. Min. Journal, Nov. 15, 1913, p. 777.
Min and Sci. Press, Sept. 27, 1913, pp. 484-485.
REID, FRASER D.
"Milling at Cobalt,"
Min. and Sci. Press, Aug. 9, 1913, pp. 216-217.

1914.—JOHNSTON, JAS.
"The Mill and Metallurgical Practice of the Nipissing Mining Company, Ltd., of Cobalt, Ontario, Canada,"
A.I.M.E. Transactions, Vol. XLVIII, 1914, pp. 3-32.
Abstract in Can. Min. Journal, Feb. 1, 1914, pp. 99-100, under the title "Cyaniding Silver Ores at Nipissing Mine, Cobalt."
Can. Min. Journal, March 15, 1914, pp. 205-210; 238-241.

1914—ENG. AND MINING JOURNAL, EDITORIAL, May 16, 1914, pp. 1005-1006.
"Treatment of Complex Silver Ore."
CLEVENGER, G. H.
"The Mill and Metallurgical Practice of the Nipissing Mining Co., Ltd., Cobalt, Ontario, Canada,"
A.I.M.E. Transactions, Vol. XLIX, pp. 156-182.

1915.—CLEVENGER, G. H.
"Note upon the Occurrence of Mercury in the Cobalt Ores,"
Economic Geology, Vol. X, 1915, pp. 770-772.
ENG. AND MIN. JOURNAL EDITORIAL, June 26, 1915, p. 1120.
"Phillips' Process for Treating Cobalt-Silver Ores,"
THORNHILL, E. B.
"Recovery of Mercury from Amalgamation Tailing, Buffalo Mines, Cobalt,"
A.I.M.E. Transactions, Vol. LII, 1915, pp. 165-170.
FRENCH, HERBERT J.
"Flotation Tests on Cobalt-Silver Ores,"
Can. Min. Journal, July 1, 1915, pp. 400-401.

1916.—BRIDGES, RALPH.
"Metallurgy of the Ores from Cobalt, Ontario,"
1. "Method of Treatment at the Cobalt Plant of the Canadian Copper Company,"
Can. Min. Journal, Jan. 15, 1916, pp. 48-50.
Eng. and Min. Journal, April 8, 1916, pp. 646-647.
2. "Loss of Silver in Chloridizing Speiss,"
Can. Min. Journal, Feb. 1, 1916, pp. 68-69.
3. "Leaching of Chloridized Speiss with Cyanide,"
Can. Min. Journal, March 15, 1916, pp. 134-135.
HUGHES, BEN.
"Concentrating Cobalt-Silver Ores by the Oil Flotation Process,"
Can. Min. Journal, Aug. 1, 1916, p. 365.

1917.—WATSON, R. B.
"Sodium Sulphide Precipitation of Silver at the Nipissing Mine,"
Can. Min. Inst. Transactions, Vol. XX, 1917, pp. 6 et seq.

Dye, Robt. E.
"Milling Practice at the Buffalo Mines, Cobalt,"
Can. Min. Inst. Transactions, Vol. XX, 1917, pp. 11 et seq.
Callow, J. M.
"Notes on Flotation,"
A.I.M.E. Transactions, Vol. LIV, 1917, pp. 3-25.
Callow, J. M.
"McKinley-Darragh-Savage Flotation Plant, Cobalt,"
Eng. and Min. Journal, Feb. 10, 1917, p. 279.
Watson, R. B.
"Notes on Metallurgy at Cobalt during 1916,"
Can. Min. Journal, March 1, 1917, pp. 102-103.
Wright, S. B.
"S. F. Kirkpatrick's Contributions to Metallurgy of Cobalt Silver Ores,"
Can. Min. Journal, Aug. 1st, 1917, p. 305.
Thornhill, E. B.
Dye, Robt. E.
Cole, A. A.
Groch, Frank.
"Flotation Process at Cobalt, Notes on,"
Ont. Bur. Mines Reports, Vol. XXVII, Part 1, 1917, pp. 127-130.

1918.—Drury, Chas. W.
"Development of the Metallurgy of the Ontario Silver-Cobalt Ores,"
Ont. Dept. of Mines Report, Vol. XXVII, 1918, Part III, Cobalt, pp. 64-69.
Wright, Sydney B.
"The Smelting and Refining of Cobalt Silver Ores,"
Can. Min. Inst. Transactions, Vol. XXI, 1918, p. 992.
Groch, Frank.
Simpson, W E.
" The Groch Flotation Machine,"
C.M.I. Transactions, Vol. XXI, 1918, pp. 145-150.

1919.—Wright, Sydney B.
"Smelting and Refining of Cobalt Silver Ore,"
Min. and Sci Press, Jan. 25, 1919, pp. 125-126.

Fairlie, M. F.
"Extraction of Silver from Ores,"
Pitman's Common Commodities. By Benjamin White.

Descriptions of milling practice are also given in the annual reports of the operating companies; in the annual reports of the Ontario Department of Mines: in Mr. A A. Cole's annual reports to the Temiskaming & Northern Ontario Railway Commission.

CHAPTER V

LITERATURE ON GEOLOGY[1]

By Cyril W. Knight

INTRODUCTION

Before the discovery of Cobalt in 1903, detailed geological work had not been accomplished in the Cobalt silver area. This was due chiefly to the fact that no ore-bodies had been discovered which were of sufficient importance to encourage accurate geological surveys, and partly also to the fact that the region was remote from railways and was settled in but one or two isolated places, such as Haileybury, New Liskeard, and a few localities on the east side of Lake Timiskaming.

Accordingly the reports on the geology were general in character, and the geological maps faulty and published on a small scale.

There is little necessity in this review of the literature to summarize the early reports published prior to 1903, of which there are only a few. Sir William Logan wrote the first general account of the rocks when he examined the shores of Lake Timiskaming in 1845-46. The only other report of importance was written by Dr. Alfred E. Barlow many years after, in 1897. Barlow covered a very great area, 6,912 square miles, and published a geological map extending from Lake Nipissing on the south to the head of Lake Timiskaming on the north. In such a vast area, it was clearly impossible with the financial resources then available to do detailed geological work. But Barlow's topographic survey of the main waterways was extraordinarily accurate and will remain a monument to his careful and painstaking labour. Moreover, he mapped in a general way the outlines of the diabase and suggested that in certain localities it appeared to occur in the form of a sheet or sill. In later years Miller named this rock the Nipissing diabase and showed that it was the source of the silver ores.

Thus there are but two reports of importance in the period preceding the discovery of Cobalt, that by Sir Wm. Logan and that by Dr. Alfred E. Barlow.

Any one desirous of delving into the literature of that time will find an excellent review in Dr. Barlow's report and in Bulletin No. 360 of the United States Geological Survey.

It may be noted here, however, that the discovery of a body of silver-lead ore, the Wright silver mine, on the east shore of Lake Timiskaming, was made in the year 1686. A very interesting account of the finding of this deposit has been written by Mr. J. A. McRae. A reprint of Mr. McRae's article will be found in following pages.

Coming now to the second period, namely, that following the discovery of Cobalt, a higher standard begins to develop in the literature dealing with Cobalt and other great camps of northeastern Ontario. The reports cover smaller areas and the maps are on a larger scale and of increasing accuracy and exactness. In the twenty-one years which have elapsed since the discovery of Cobalt, the complex structure of the rocks has gradually been unravelled. Its complexity, indeed, is much greater than was imagined by the early geologists. If we compare, for example, Barlow's summing up in the year 1897, of the age relationships of the rocks with that of to-day, it will be seen that the advance in the science of geology has been rapid and great.

---

[1] The list of reports on milling and metallurgy is given in Chapter IV.

Barlow, for instance, divided the rocks into the following simple divisions:—

PALEOZOIC		Silurian, Cambro-Silurian.
ARCHEAN	Huronian	Diabase and gabbro, conglomerate, greywacké, quartzite.
	Laurentian (including Grenville series)	granite, gneiss, crystalline limestone.

If this table be compared with the table showing the complex subdivisions given in the legend on page 30 of this report, a proper understanding of the advance in our knowledge of the geological history of the area will be realized. It should be noted, however, that Barlow's report did not cover the Matachewan area in which the Matachewan series was subsequently discovered by Burrows.[1]

In the second period, that following the discovery of Cobalt, the outstanding report on the Cobalt silver field is that by Dr. Willet G. Miller, which was published in four editions.

In the following summaries, it is not practical to attempt to summarize fully the four editions of Miller's report; any one desirous of becoming familiar with the geology of the Cobalt area must consult Miller's work. As noted elsewhere copies of his report are still available. Certain parts of Chapter I of the present report give Miller's conclusions in regard to the general geology, ore deposits, and mineralogy. It is not necessary, therefore, to repeat these summaries in Chapter V.

In addition to the reports summarized below, there will be found much information on mining and the treatment of the ores in the annual reports of the Temiskaming and Northern Ontario Railway by Arthur A. Cole.

The annual reports of the mining companies also give much information, particularly regarding costs of mining and treatment of the ores.

A few of the papers which have been written on the Cobalt silver field are not mentioned or summarized in the following pages. Some of these are brief notes, or discussions, which would not add much to the value of this chapter.

The literature has grown to such proportions that the summaries are of necessity, for the most part, brief.

SUMMARIES OF LITERATURE

Miller,[2] in December, 1903, publishes the first report on Cobalt a few months after the deposits were discovered. In view of the importance of this paper it is reprinted below in full:—

> During the last month, the discovery of deposits of cobalt-nickel-arsenic and silver ores in the northern part of the Province of Ontario has been made public. Little importance appears to have been attached to the deposits by those who first saw them, it being thought that they carried a small amount of copper, the niccolite being mistaken for this metal. The Director of the Bureau of Mines,[3] however, when on a recent visit to the district, received specimens of the minerals, and recognized that they represented valuable ore. The writer was, accordingly, instructed to make as thorough an examination of the deposits and surrounding area as could be made at the season of the year, snow having already begun to fall in the district.
>
> The deposits were discovered during the building of the Temiskaming & Northern Ontario, the government railway, which is now under construction from North Bay junction, on the Canadian

---

[1] The Matachewan Series and its pre-Cambrian Relations, by Willet G. Miller; Can. Min. Jour., April 20, 1923.

[2] Cobalt-Nickel Arsenides and Silver in Ont., by Willet G. Miller; Eng. Min. Jour., Dec. 10, 1903; Can. Min. Rev., Vol. 22, No. 12, Dec. 31, 1903, pp. 245-249.

[3] Thos. W. Gibson.

Pacific, to the head of Lake Temiskaming. The road-bed of this new railway runs almost over the top of the first of the deposits discovered. The deposits lie five miles south of the village of Haileybury, one of the two sister villages on the Ontario side of the northern part of Lake Temiskaming. Haileybury, following the railway, lies about 106 miles north of North Bay station, which is, by the Grand Trunk Railway, 227 miles north of the city of Toronto.

As the deposits were discovered quite recently, and snow has fallen in that district, very little prospecting has been done in the surrounding area. The discoveries were made by men employed on the railway, and not by regular prospectors; hence the work has not been done as systematically as it might have been.

When I visited the locality, recently, four veins or deposits had been located in the vicinity of a small body of water known as Long lake, which is not shown on existing maps. It lies about one-half mile south of the southern boundary of lots 8 and 9 in the first concession of the township of Bucke. The reports of other finds were not verified.

Each of the four veins visited was found to carry cobalt. Nickel also appears to be present in all of them; but as the weathering of the cobalt compounds masks, at times, the nickel colours, this latter metal was not definitely recognized in two of the deposits, although it doubtless occurs wherever the cobalt is found. Three of the veins are rich in native silver. The veins occur in unsurveyed territory, and, as the locations are as yet unnamed, we shall speak of them as Nos. 1, 2, 3 and 4. The outcrop of No. 2 lies about one-half mile southwest of No. 1, and No. 3 the same distance southwest of No. 2. The outcrop of the fourth vein is about one-half mile southeastward of No. 3.

Very little work has been done on any of the veins, and as the surface is pretty well filled by moss and soil, it is impossible to state what is their horizontal extent.

All of the veins cut through one or both of the formations known in the district as Huronian slate and breccia-conglomerate. The latter rock is considered to be composed of volcanic ejectamenta—grains and fragments of rock of various kinds which have become consolidated. The slate conglomerate of older Canadian writers, Logan and Murray, is a variety. The slate along the railway cuts, in the vicinity of Long lake, contains occasional fragments of pink granite, which are, at times, a couple of inches or more in diameter. On the faces of some of the vertical cliffs, the well-banded slate at the bottom is found to pass gradually into massive breccia-conglomerate at the top, the fragments in the latter being of varied composition, and ranging in size from small grain-like fragments to pieces of rock a foot in diameter.

I have had no opportunity of making a laboratory study of the specimens of rocks collected. The presence of dikes or sheets of some of the darker-coloured eruptives was suspected, but they were not definitely recognized. In the field they would resemble rather closely some of the more massive varieties of the slate and finer-grained breccia.

The slate and conglomerate have a slight dip, and the veins referred to cut them almost vertically. The strike of veins Nos. 1 and 3 is approximately northeast and southwest; that of 4 is east and west; that of 2, northwest and southeast. Diabase and gabbro invade these fragmental rocks in some parts of the district, and appear to underlie most of the area. About three miles to the northward of Long lake, Silurian limestone overlies the Huronian, but the limestone is undoubtedly of younger age than the veins.

Vein No. 1 lies east of the railway track, at the edge of a swamp, about one-quarter mile north of the end of Long lake. It has been uncovered at three points, which are within a few yards of one another. As the surface of the rock is low here, and little of it is exposed, it is difficult to tell much about the form of the deposit. Medium grained, dark-coloured conglomerate is found on one wall. At the widest opening the deposit has a width of over 6 feet, but the vein matter is more or less mixed with rock. The ore consists of niccolite, or the arsenide of nickel, and smaltite, the diarsenide of cobalt, together with much native silver. Niccolite contains, theoretically, 43.9 per cent. of nickel and 56.1 of arsenic. Smaltite carries 28.2 per cent. of cobalt and 71.8 of arsenic. It may be added that the ore of nickel now worked in Ontario, the iron sulphide or pyrrhotite of Sudbury, in which nickel occurs not as an essential but as an accidental constituent, carries, on the average, less than 5 per cent. of the metal. On weathered surfaces the vein matter is coated with the beautiful pink decomposition product, cobalt bloom. The green nickel stain is also seen on some surfaces, but is usually masked by that of the cobalt. This nickel compound is probably the arsenate, annabergite, but nickel silicate may also be present. The secondary mineral, arsenolite, is present. The native silver occurs as films, or leaves and fine threads, or moss-like forms, through the nickel and cobalt minerals, especially in the niccolite, as well as in cracks in the rock and in the calcite veinstone. In weathered portions of the ore the silver shows distinctly. Some lumps of weathered ore, weighing from 10 to 50 lb., carry a high percentage of silver. One sheet, composed chiefly of silver, attached to a rock surface, had a thickness of nearly 0.375 inch and a diameter of about 1 foot. The silver appears to have crystallized earlier than the niccolite, which has been deposited around it. The cobalt arsenide has formed still later than the niccolite. As so little work has been done on this ore-body, it is difficult to determine whether the three openings belong to one vein, or whether the ore occurs in a more irregular deposit, although the chief opening appears to be on a vein-like body. The ore is undoubtedly very rich, containing values in nickel, cobalt, silver and arsenic, and a comparatively small vein could be worked at a handsome profit.

On location No. 2 the ore-body is distinctly vein-like in form. The ore here is a mixture of smaltite, and probably some closely related arsenides of cobalt, such as safflorite and niccolite. The only complete analysis which has yet been made of the ore from this locality was that of a sample from this vein. It was found to have the following percentage composition: Cobalt, 16.8; nickel, 7; iron, 6.3; arsenic, 69; rock matter, 0.9; total, 100. This ore-body, unlike the other three examined, carries no silver in the parts so far uncovered. Three openings have been made on the vein over a length of 300 feet. The massive ore has a width of 14 inches but vugs in the wall-rock, 2 feet or more from the vein, are filled with cobalt bloom. The rock of both walls is slate. The walls are well defined, and the vein dips almost vertically, the strike being toward the southeast. The vein lies on the hillside, a few hundred yards east of Long lake and the railway, and, unlike ore-body No. 1, is at a height of about 70 feet above the water level. Although the width of this vein is not great, the character of the ore is such as to make it promising, at the present prices of the metals contained in it.

The ore has a massive appearance, and a rather dark-gray colour, where not coated with cobalt bloom. When examined carefully, however, in hand specimens, especially if a polished surface be examined with a magnifying glass, it is seen to be a mixture of a gray mineral, which is chiefly smaltite, and the reddish mineral, niccolite. Smaltite and the corresponding arsenide of nickel, chloanthite, are claimed by most authors to pass into one another by the substitution of cobalt for nickel, and *vice versa*. Niccolite, in the analysis quoted by Dana and others, carries only a small percentage of cobalt and iron, while smaltite and the other diarsenides of cobalt frequently contain much iron and nickel. In the ore under consideration, the cobalt and nickel appear to be, for the most part, in distinct compounds. In the analysis quoted, if we consider the 7 per cent. of nickel to exist as niccolite, and the percentages of iron and cobalt, 6.3 and 16.8, respectively, to exist as smaltite, the theoretical percentage of arsenic in the ore should be 68.47, instead of 69, as found by analysis. The percentage of niccolite by weight would be 15.94, or about one-seventh part of the whole by volume, since niccolite has a somewhat higher specific gravity than smaltite. The specimens, when examined with the magnifying glass, agree with this. The niccolite has crystallized earlier than the smaltite, which forms the ground-mass through which the niccolite grains are set.

Minute, brilliant, silver-white or tin-white crystals occur sparingly, embedded in the wall-rock and in the ore. The crystals occur in cubes, and in combinations of this form with the pyritohedron, or rhombic dodecahedron, and octahedron. An analysis is required to determine whether they are smaltite, cobaltite, or some related compound. The smaltite shows a tendency to form globular or spheroidal masses, with a radiated structure. The ore is somewhat porous, spaces being left between the globules, which are tarnished almost black on their surfaces. Where not coated with cobalt bloom, the weathered surface of the ore has a dark colour, not unlike that of the wall-rock. On a fresh surface, the more massive ore resembles mispickel, but is somewhat darker in colour. Small grains of quartz are found sparingly in the ore. The proportion of nickel to cobalt in this case is less than that in No. 1. A more detailed study of the form and chemical composition of the minerals is being made.

Ore-body No. 3, so far as could be seen, is similar in character to No. 1. It lies at the southern edge of Long lake. The ore consists of native silver, smaltite and cobalt bloom, and, in all probability, niccolite also.

Vein No. 4, although having the smallest width of the four, is, in many respects, the most interesting of the group. Here a perpendicular bare cliff of rock, 60 or 70 feet high, faces west. The vein, whose width averages not more than 8 inches, cuts this face at right angles, and has an almost vertical dip. The vein is weathered away, leaving a crack in the face of the cliff 2 feet, in some places 4 or 5 feet, in depth. When I saw it first, it had not been disturbed. Thin leaves of silver up to 2 inches in diameter were lying on the ledges, and the decomposed vein matter was cemented together by the metal, like fungus in rotten wood. It was a vein such as one reads of in text books, but which is rarely seen, being so clearly defined and so rich in contents. It was found impossible to get a fresh sample of the ore with the prospecting-pick, the vein being so much decomposed. The weathered specimens, however, in addition to the native silver, contained cobalt bloom; and the unaltered ore will be found, in all probability, to consist of smaltite and niccolite, in addition to the silver. It may also be added that, in one part of the vein, a distinct banded structure was noticed. Across a distance of 8 inches there were 12 or 14 layers of ore lying parallel to the walls. At the bottom of the cliff the vein cuts thin, banded, dark-gray or greenish, at times almost black, slate, which has a slight dip. This slate passes gradually, so far as could be determined from the steep character of the cliff, into coarse breccia-conglomerate in the upper part. The fragments in the conglomerate consist of quartz-slate, granite and other rocks.

On some of the weathered surfaces of the native silver specimens there are small, black, spheroidal masses, with little lustre. These appear to be the hydrated oxide of cobalt, heterogenite. Some of the deposits on the silver resemble asbolite. The carbonates of cobalt and nickel are also probably present. Antimony and sulphur have been detected in the ore of veins 1 and 2. Detailed analyses are required to determine the character of some of the silver-bearing minerals, which are present in small amounts. Bismuth, copper and manganese, in an association of ores such as we have in these deposits, are to be looked for.

These recently-discovered ore-bodies lie about 90 miles northeast of the town of Sudbury, in the vicinity of which are situated the well-known nickel mines. The ore of the latter is of a different character from that of the Haileybury deposits, being essentially pyrrhotite and copper pyrite. The rock associated with the Sudbury deposits, which are not veins, but deposits of irregular shape, is norite, a variety of gabbro; the ore itself is claimed by most writers to be of igneous origin. It is thus seen that there is little in common between the ore-bodies of the two localities, with the exception that nickel is a characteristic metal of each. The Sudbury pyrrhotites carry a small percentage of cobalt in addition to nickel. The minerals niccolite, danaite, and other arsenical compounds, have been found in some of the Sudbury deposits, but only in small quantities.

It is of interest to note that a deposit of sulph-arsenide of iron, mispickel, was discovered a few years ago near Net lake, which lies about 25 miles to the southwestward of the Haileybury deposits. This mispickel, however, does not carry appreciable amounts of nickel, cobalt or silver.

On the Quebec side of Lake Temiskaming, about nine miles to the northeastward of the Haileybury deposits, a deposit, known as the Wright silver mine, was discovered many years ago by some of the early explorers of that region. During recent years, this deposit has been worked for its lead and silver contents. The deposit is unique in character, the wall-rock being Huronian breccia-conglomerate, the fragments in which are, at times, cemented together by argentiferous galena.

The only area in Ontario or central Canada which has hitherto been found to contain deposits of rich silver ore is that which lies near the head of Lake Superior. While native silver has been found in considerable quantity in these deposits, the sulphide, argentite, is the more characteristic ore. The Silver Islet mine, near Port Arthur, is well known to those interested in the metal industry. Deposits of somewhat similar character, which occur on the mainland, have also been frequently described. The report of Mr. E. D. Ingall, of the Canadian Geological Survey, published some years ago, gives a particularly full account of this silver-bearing area.

The silver veins in the vicinity of Port Arthur, like those of Haileybury, cut through slate, but the Port Arthur slates are held to be of later age—Animikie—than those of Haileybury, which are what is called, in a general way, Huronian. Much work remains to be done on our metamorphic and igneous rocks before the various formations can be correctly correlated. Both the Port Arthur and Haileybury slates have been disturbed by eruptions of diabase and related rocks.

Although cobalt and nickel minerals have not been found in quantity near Port Arthur, it is interesting to know that the ore of the Silver Islet and some of the other mines was, at times, found to be coated with cobalt bloom. Niccolite and other minerals carrying cobalt and nickel occur in small amounts in some of these deposits. The only deposit in which quicksilver has been found in Ontario is that of Silver Islet, where chloride of silver is also said to occur as a decomposition product.

Small quantities of cobalt, nickel and silver-bearing minerals occur on Michipicoten island, Lake Superior. Arsenical compounds of the first two metals have been found at several other localities in Ontario and at Calumet island, Quebec. It will be noticed that the association of minerals in these Haileybury veins is not unlike that found in some well-known deposits of Germany and other countries.

Although little prospecting has been done in the vicinity of the Haileybury deposits, it would appear, from the discoveries already made, that ore-bodies occur there which can be worked profitably for the metals which have been mentioned. It is scarcely probable that nickel will be found in sufficient quantity in these deposits to interfere materially with the lower grade, but large, deposits of the Sudbury area.

Slate and conglomerate, similar in character to those of Long lake, cover a very large, as yet little prospected, area in northern Ontario. These rocks, along the government railway, a considerable distance south of the deposits described in this paper, contain indications of the presence of cobalt ore.

It is stated in "The Mineral Industry" that "cobalt, which is used in the arts, chiefly in the form of oxide, is obtained from New Caledonia, Australia and Germany, and smelted in France, Germany and Great Britain, the Messrs. Vivian, of Swansea, being the chief buyers in the last-named country." Cobalt oxide is produced at one plant in the United States.

The ore of New Caledonia, which is the world's largest producer, shipping about 3,000 tons yearly, is cobaltiferous wad, containing 25 to 30 per cent. manganese and 2 to 8 per cent. cobalt oxide (CoO). The ore of New South Wales is similar in character. In both countries the cobalt ore is a decomposition product, and occurs in irregular deposits, similar to those of bog iron ore.

At the end of 1901 and the beginning of 1902 the price of cobalt ore, containing 4 per cent. cobalt, in New Caledonia, was forced up higher than circumstances warranted. For a long time the price in Europe did not justify more than 90 fr. per ton being paid for this quality of ore at the mines, but the price steadily rose to 330 fr. (about $66) until recently, since which it has receded. The black oxide of cobalt sells at from $2.26 to $2.30 per pound, or the metallic cobalt in the compound brings about $3 per pound. It would thus seem that the refiners should make a much larger profit than the miners. The market will not, however, stand a greatly increased production without the prices materially decreasing. It is claimed that there has been a combination among refiners to keep up the prices of the artificial cobalt products.

I would be pleased to receive inquiries from buyers of Cobalt ore, and other minerals which are associated with it in the vicinity of Haileybury, with the object of putting them into communication with producers. Shipments could be made during the coming winter.

Miller,[1] in 1904, gives a preliminary description of the rocks and of the four veins first discovered around Cobalt lake. This paper is substantially the same as that published in the "Engineering and Mining Journal" on December 10th, 1903. Some further material is, however, added.

---

[1] The Cobalt Nickel-Arsenides and Silver Deposits of Timiskaming, by Willet G. Miller, Ont. Bur. Mines, Vol. XIII, pt. I, pp. 96-103.

Barlow,[1] in 1904, finds that the iron formations at the northeast part of Lake Timagami belong to a much older series than what he had hitherto described as Huronian in this district. The iron formations with accompanying green schists, slates, dolomites, and schistose eruptives, and intruded by granites, belong to a series which had been intensely folded, metamorphosed, and considerably eroded before the deposition of the overlying conglomerate hitherto described as the basal member of the Huronian system in this region. The larger fragments in the conglomerate are principally pebbles of granite and greenstone derived from the degradation of this underlying series.

Barlow believes that the Vermilion iron range of Minnesota is very closely related, if not identical in character and age with the iron-bearing ranges outcropping in the vicinity of Lake Timagami. Both have highly inclined attitudes with very brilliant associated jaspers.

Parks,[2] in 1904, describes the veins and rocks in the area around Cobalt lake, and also the rocks north of Lake Timiskaming.

The age to be ascribed to the rocks around Cobalt and their position in the complex formations constituting the most ancient rocks of the earth, is a matter to be approached with some hesitation. When the greatest authorities differ it is very difficult to decide on the proper nomenclature.

Young,[3] in 1904, finds that in the area between Rabbit and Timagami lakes the oldest series of rocks consists chiefly of schists, chloritic, sericitic, and hornblendic. The schists are penetrated by masses of granite and syenite. The schists, granite, and syenite are unconformably overlain by conglomerate, slate, and quartzite. These sediments rest horizontally and are frequently capped by sills of diabase. The different areas of diabase throughout the district are, it is tolerably certain, all parts of a once continuous sill.

Miller,[4] in 1905, publishes his first full report on Cobalt. This report was based on field work of 1904. He classifies the rocks according to the following table:—

NIAGARA..............Limestone with a small amount of sandstone and conglomerate at its base.

Great unconformity

PRE-CAMBRIAN

DIABASE AND GABBRO...Animikie or Keweenawan in age.
MIDDLE HURONIAN......Lorrain arkose, quartzite, and conglomerate.

Unconformity

LOWER HURONIAN.......The Cobalt series, consisting of conglomerate, breccia, quartzites, and greywacké-slate.

Great unconformity

KEEWATIN.............An igneous complex, consisting of greenstones, quartz-porphyries, and other rocks.

Igneous contact

LAURENTIAN...........Lorrain granite.

---

[1] The Timagami District, by Alfred E. Barlow, Sum. Rept., Geol. Surv. Can., 1903, pp. 120-132.

[2] The Geology of a District from Lake Timiskaming Northward, by Wm. A. Parks, Geol. Surv. Can., Vol. 16, 1904, pp. 198A-255A.

[3] On Surveys between Rabbit and Timagami Lakes, by G. A. Young, Sum. Rept., Geol. Surv. Can., 1904, pp. 195-198.

[4] The Cobalt-Nickel Arsenides and Silver Deposits of Timiskaming, by Willet G. Miller, Ont. Bur. Mines, Vol. XIV, pt. II, 1905.

In the Lower Huronian (Cobalt series) conglomerate, he finds granite boulders of great size and he speculates as to the possibility of the conglomerate being glacial in origin. He thinks that in the present state of our knowledge there is little warrant for claiming that these granite boulders, often two or three feet or more in diameter and distant a couple of miles from exposures of the rock, indicate glacial conditions during Lower Huronian times, although there is no proof to the contrary.

He believes that the material in the silver veins has, in all likelihood, been deposited from highly heated and impure water which circulated through the cracks and fissures of the crust and were probably associated with the diabase eruption.

Bell,[1] in 1905, reports on the Cobalt mining district.

Hardman,[2] in 1905, describes a new mineral area in Ontario.

Campbell and Knight,[3] in June, 1906, work out the paragenesis of th cobalt-nickel arsenides and silver deposits of the Cobalt area. Beginning with the earliest they believe the following to be the order in which the minerals were deposited: (1) smaltite-chloanthite, (2) niccolite, (3) calcite, (4) argentite, (5) native silver, (6) decomposition products (erythrite, annabergite, etc.). This order was worked out by examining polished surfaces of the ore by means of reflected light under the microscope.

Campbell and Knight,[4] in September, 1906, make a microscopic examination of polished surfaces of the silver ores from Cobalt. Although all of the structures met with in this examination cannot be satisfactorily explained, they point to the following order of origin for the principal constituents: First came the smaltite, closely followed by the niccolite; other minerals in small amount came down at this time. Then, after a period of slight movement in which the first minerals were more or less fractured, calcite was deposited as a ground-mass. Later came argentite, which was followed by native silver and native bismuth. Lastly came the surface decomposition products, erythrite and annabergite.

Arranged in tabular order, the succession is then as follows:—

Smaltite.
Niccolite.
Period of movement and fracturing.
Calcite.
Argentite.
Native silver.
Native bismuth.
Period of decomposition.
Erythrite and annabergite.

Miller,[5] in 1906, publishes the second edition of his report on Cobalt. This is substantially the same as the first edition.

Van Hise,[6] in 1907, after having spent about a month during each of two seasons in the Cobalt area, is convinced that there have been two periods of concentration in the ore deposits. The first concentration occurred under deep-seated conditions when the waters were free from oxygen; during this first period arsenical, antimonial, and sulphur compounds of cobalt, nickel, and silver were deposited. He does not know whether these waters were atmospheric or magmatic, or partly one and partly the other. Since the first concentration there has been a second concentration through the influence of surface waters bearing oxygen and descending or travelling laterally. An adequate explanation of the ore deposits must combine the effects of the deep-seated and shallow circulations.

---

[1] Cobalt Mining District, by Robt. Bell, Sum. Rept., Geol. Surv. Can., 1905, pp. 94-104.

[2] A New Mineral Area in Ontario, by J. E. Hardman, Can. Min. Rev., Vol. 24, No. 5, May, 1905, pp. 95-98.

[3] The Paragenesis of the Cobalt-Nickel Arsenides and Silver Deposits of Timiskaming, by W. C. Campbell and C. W. Knight, Eng. Min. Jour., June 9, 1906.

[4] A Microscopic Examination of the Cobalt Nickel Arsenides and Silver Deposits of Timiskaming, by W. Campbell and Cyril W. Knight, Econ. Geol., Vol. 1, No. 8, Sept.-Oct., 1906.

[5] The Cobalt-Nickel Arsenides and Silver Deposits of Timiskaming, by Willet G. Miller, Ont. Bur. Mines, 1905, pt. II.

[6] The Ore Deposits of the Cobalt District, Ont., by C. R. Van Hise, Jour. Can. Min. Inst., 1907, Vol. 10, pp. 45-61. The above is largely quoted word for word from the original article.

It appears that at least the major portion of the cobalt-bearing minerals, smaltite and cobaltite, are products of an early concentration. These minerals were doubtless deposited at a considerable depth below the surface. At this time the openings were largely or altogether filled with vein material, smaltite, cobaltite, and gangue materials.

After the main deposition of the cobalt minerals, there were movements which resulted in secondary fracturing of the veins. These openings permitted the entrance of silver-bearing solutions and the contact of these solutions with the cobalt minerals resulted in the precipitation of the silver. It is a well-known fact that if silver solutions are placed in contact with cobalt and nickel sulphides and arsenides under ordinary conditions, these minerals will precipitate the silver. Thus he inclines to the view that the cobalt minerals appeared comparatively early, and that later the silver-bearing solutions appeared, which resulted in the silver minerals. In presenting this view he does not mean to say that the deposition of the cobalt minerals had ceased before the silver began to be deposited, for the two may have overlapped to a considerable extent.

It appears certain that the extremely rich, superficial deposits of a few feet in thickness, connected with the zone of weathering, are due to secondary concentration under surface conditions. This statement refers to the nugget horizon which is so rich in silver and in which the smaltite and cobaltite have been largely altered into secondary minerals, or have been leached out altogether. It is practically certain that this extraordinarily rich upper film in the Cobalt area has been produced by two concentrations, one under deep-seated conditions when atmospheric waters were not present, and the other under surface conditions when atmospheric waters were present.

Van Hise points out that it must be remembered that in the past the veins which now stop abruptly at the surface continued upward to an unknown height into what is now the atmosphere. Erosion has cut away this upper material. This process has been a very slow one. At any given time the silver salts at or near the surface were being oxidized to a soluble form and were being carried down in the openings of the veins. At or near the level of groundwater the silver in the solutions would again be precipitated by the cobalt minerals. These reactions would take place with the arsenical and antimonial silver-bearing minerals as well as with argentite, although the latter case is more simple. The argentite in the upper part of the belt is oxidized to silver sulphate which is readily soluble. As this salt is carried down and comes in contact with the cobalt minerals, native silver is precipitated, just as silver is precipitated from silver sulphate in a beaker when in contact with such minerals.

As the process of erosion, solution, and deposition goes on, the material, once enriched as the result of erosion, reaches the surface and goes through the same process as before. In this manner, a layer of rich material is accumulated at the surface. Thus the nugget zone is produced.

But the majority of the mines do not depend upon this very rich superficial film, but upon the main horizon below. To what extent is this deeper horizon the result of a single concentration under deep-seated conditions and of a later concentration under surface conditions? To this question he is unable to give a definite answer, but he believes that the later secondary concentration, even for this belt, has made important additions to the silver values and may have been an important factor throughout the horizon. Whether the chief values of silver are thus explained or were produced under deep-seated conditions in the later stages of the Cobalt deposition, is a point for the future to decide.

He believes the diabase is the source of the ore. The diabase sheet cooled first along the contacts. Consequently, when the main mass was still molten the exterior was solid. During cooling, contraction took place, earth movements occurred, and openings were found not only in the conglomerate and Keewatin, but in the solidified diabase itself. Later, when these openings became filled by deposits from circulating solutions, they formed the veins of the area. Thus openings in the outer solid part of the diabase may be filled with silver-bearing solutions which are derived from the diabase itself. If this theory is correct, what would be expected as to the distribution of the ore-bearing veins? He imagines that the diabase would be most likely to bear productive veins in contact with or close to the older rocks because these are the parts first cooled. If this theory is correct, veins should be found in the conglomerate and Keewatin in those parts of these formations which are close to the diabase.

He believes that the Keewatin and conglomerate are the main sources of the calcite of the veins.

He suggests that the solutions bearing calcium carbonate were a factor in the precipitation of the metalliferous minerals. It is probable that precipitation was largely caused by the mingling of solutions which were derived from the diabase, Keewatin, and conglomerate, although the mere cooling of the solutions may have been a factor in the process.

He suggests that the favourable places to explore are those in the conglomerate and Keewatin along the border of the diabase; and the favourable place in the diabase itself is comparatively near its border.

Present knowledge warrants cautious attempts to explore the conglomerate below the diabase for silver veins. If the conglomerate under the diabase proves to be profitable, it will furnish information as to the relative importance of the primary and secondary concentrations; for the ores below the diabase will be largely those produced by the deeper circulation, and comparatively little affected by the secondary concentration.

Following the presentation of this paper by Van Hise, a discussion took place in which Messrs. Ingall, Hixon, Parks, Van Hise, Coste, Bell, Miller, Tyrrell, and Brock took part. In replying to some questions, Van Hise said he did not know how much of the silver was deposited by the secondary surface concentration nor what proportion was produced under deep-seated conditions.

Miller said he did not think there was any question at all that there were two periods of deposition. Miller also discussed an important feature of the veins. He gave reasons why the silver in the veins disappeared when the veins passed down into the Keewatin rocks. There are a number of veins which pass from the conglomerate down into the Keewatin. They hold their width pretty well in passing—not all, but some of them. Now in practically all cases, that is in the area west of Peterson lake, the silver values disappear when they go to the Keewatin, but the smaltite and niccolite continue below the contact. The only explanation he could give for this was that during this period of secondary disturbance the silver filled in the cracks through the smaltite or other minerals. The silver is always found in the secondary cracks; but during this period of secondary disturbance, the Keewatin being the older mass, the igneous formation differing from the conglomerate seems to have escaped the effects of this slight disturbance, hence there were no cracks in it, and the solutions could not get through the Keewatin. They could work through the vein in the over-lying conglomerate, but the vein in the Keewatin escaped. It seemed to him that this was pretty conclusive evidence of two periods of deposition: an older period of deposition of nickel and cobalt minerals, and a later period of deposition of silver minerals. Referring to the question of carbonaceous material, Miller said that there was considerable graphite in one of La Rose veins. There is also much graphite in the Cobalt hill vein, a massive vein of smaltite and niccolite 14 inches wide, where there is no silver at all.

Ledoux,[1] in 1907, shows the grade of the Cobalt ores as determined at his sampling works in Jersey City. Since January, 1905, he has handled at the works, 366 carload lots of ore and 52 other lots, less than carloads, including what are called nuggets. The nuggets are not pure silver, but run anywhere from 700 to 870 parts of silver in the thousand. There are more or less gangue and other materials associated with the silver, and the metallic silver itself, visibly free from gangue, runs about 950 fine. Leaving out of consideration the nuggets and native silver and including only the lots of regular ore, a review of 394 lots sampled shows that the highest lot ran 7,402 ounces of silver to the ton, the next in order being 6,909, 6,413, 6,163, and 5,948 ounces per ton. In the 394 lots he found that 40 per cent. of the lots contained from 1,000 to 7,402 ounces of silver to the ton. The highest per cent. of cobalt found in any one shipment is 11.96 per cent., the average being 5.99 per cent. The highest assay for nickel in any car is 12.49 per cent., the average being 3.66 per cent. The highest per cent. of arsenic is 59.32 per cent., the average 27.12 per cent.

Bell,[2] in 1907, gives a general account of the rocks and veins at Cobalt.

Tyrrell,[3] in 1907, concludes that the cobalt and silver veins were formed in V-shaped fissures which taper from above downwards; that, although they were formed by mineral-bearing waters which rose from deep-seated sources, and were associated with the latest stages of the eruption of diabase, having probably risen through the same vents with it, these waters spread out laterally through cracks and openings in the mushroom-shaped top of the laccolith of diabase and descended into the fissures in the rocks beneath it; that the veins were thus originally formed by deposition from waters which locally descended from above, rather than ascended from below, as in most normal veins; and finally that the veins were superficially enriched at a later period by atmospheric waters descending through portions of the veins which have since been eroded away.

Miller,[4] in 1907, publishes the third edition of his report on Cobalt. This edition has been enlarged. More detailed descriptions are given as to the character of the rocks. A chapter on the working mines of Cobalt has been added by E. T. Corkill, and also a chapter on the Montreal River area and South Lorrain by Cyril W. Knight. A description of the Bloom Lake area is given by W. R. Rogers, and a report on Casey and Harris townships, and Wendigo lake by R. E. Hore. Mr. J. S. DeLury describes an area west of Bay lake.

---

[1] Richness of Cobalt Ores, by Albert R. Ledoux, Jour. Can. Min. Inst., 1907, Vol. 10, pp. 62-68.

[2] The Cobalt Mining District, by Robt. Bell, Jour. Can. Min. Inst., 1907, Vol. 10, pp. 62-68.

[3] Vein Formation at Cobalt, Ontario, by J. B. Tyrrell, Can. Min. Jour., Aug. 1, 1907, pp. 301-303.

[4] Cobalt-Nickel Arsenides and Silver Deposits of Timiskaming, by Willet G. Miller, Ont. Bur. Mines, Vol. XVI., 1907, pt. II.

Gibson,[1] in 1907, gives an account of the first discoveries of silver at Cobalt He says:—

> The discovery of the Cobalt silver camp was one of the most significant events in the story of the mining industry of Ontario. The region was not a remote one, being close to the shores of Lake Temiskaming whose waters were known to the voyageurs of two centuries ago, and was in later times for years the scene of active lumbering operations, yet its mineral riches, though in many places lying actually on the surface, remained undiscovered until accidentally stumbled upon in the summer or fall of 1903.
>
> The first discovery seems to have been made by James H. McKinley and Ernest J. Darragh, described as "lumbermen and prospectors," who on 14th August, 1903, made a joint application to the Department of Crown Lands for a location situated "about 600 feet southeasterly from the ninth mile, say between stations 54 and 64, south from New Liskeard, of the Temiskaming and Northern Ontario Railway line as now located and graded." The application was not accompanied by the required affidavit showing discovery of mineral, but this was supplied on 6th October, and gave the date of discovery as the 7th August previous, the find consisting of rock ascertained by assay to contain "a goodly percentage of free or native silver." According to the papers, McKinley and Darragh were joint discoverers. The location was surveyed by W. J. Blair, O.L.S., as J.B. 1, containing 32 acres. Subsequently, four acres of the bed of Cobalt (then known as Long) lake in front of J.B. 1, and the mining rights of the road allowance between these two parcels, containing two acres, were granted. The discovery on J.B. 1 was developed into the well-known McKinley-Darragh mine, now owned and operated by the McKinley-Darragh-Savage Mining Company.
>
> While silver appears to have been the first mineral of value actually discovered in Cobalt, the active history of the camp begins with the finding of niccolite (kupfer-nickel) on what is now the La Rose mine, perhaps the most famous of all the Cobalt deposits. Fred La Rose, a blacksmith employed in construction work on the T. & N. O. railway, then being graded, when not engaged in sharpening "steel" for the rock-men, was accustomed to poke about the rocks in the neighbourhood of his smithy. In doing so he uncovered some pinkish material and a little digging disclosed samples of a heavy copper-coloured mineral, which in reality was niccolite, hitherto found in Ontario only in minute quantity, and known practically in this Province to mineralogists only. La Rose applied to the Department on 29th September, 1903, for a location described as being opposite station 113 on the T. & N. O. railway about 1,300 feet from Long lake at the mouth of Rock creek about one mile from the south boundary of the township of Bucke. The date of the discovery is given in the affidavit as 15th September, 1903. The claim was afterwards surveyed by John Shaw, O.L.S., as J.S. 14, containing 37 acres, being a 40-acre tract less the right of way of the T. & N. O. railway which crosses the western half of the parcel almost diagonally. La Rose's affidavit (which is signed Fred "Rose") describes his discovery as of one of copper, which was not an unnatural mistake under the circumstances, especially as La Rose was not a prospector, and knew nothing whatever about minerals. Neil A. King, a fire ranger on the T. & N. O. line, subsequently (on 8th October, 1903) filed a claim for 160 acres, being "80 acres south of lot 8 first range township of Bucke, also 80 acres south of lot 9 first range" of said township, a description which included the La Rose parcel. King dated his discovery on 16th May, 1903, also describing the mineral found as "copper ore." A hotly contested dispute between La Rose and King—or their assignees—followed, which was decided in favour of La Rose. The latter and his associates had at first entirely failed to recognize the native silver which lay blackened by exposure in plates and nuggets on the surface of the vein, both in place and in the form of boulders. These were pointed out to them by Prof. Miller, Provincial Geologist, who visited and examined the veins in the early part of November, 1903. Mr. Miller's reports really made known these remarkable discoveries to the public.

Coleman,[2] in 1907, extracted from the conglomerate at Cobalt a few stones showing well marked striations, confirming a conclusion which he had reached some time before that the Lower Huronian conglomerate is an ancient boulder clay.

Barlow,[3] in 1908, discusses the origin of the silver in James township in the Cobalt area. He regards the vein filling as of pegmatitic origin, having the same genetic relationship to diabase that ordinary pegmatite has to granite. He prefers the term diabase-pegmatite in preference to the term aplite. Some of the veins are made up almost wholly of red feldspar, which is almost always a plagioclase near the acid end of the series, together with a subordinate amount of calcite and quartz. The quartz sometimes forms graphic intergrowths with the feldspars. Other veins are made up of an almost equal proportion of plagioclase and calcite and sometimes quartz, while still others present a finer-grained feldspathic portion in the vicinity of the walls, with the whole mass of the interior made up of coarse-grained calcite and sometimes a little quartz.

---

[1] Thos. W. Gibson, Ont. Bur. Mines, Vol. XVI., pt. I, p. 7.

[2] Am. Jour. Sci., Vol. 23, 1907, pp. 187-192.

[3] The Origin of the Silver of James Township, Montreal River, by Alfred E. Barlow, Jour. Can. Min. Inst., 1908, Vol. 11, pp. 256-273.

Hore,[1] in 1908, suggests that the arsenides and sulphides of the Cobalt veins have been concentrated from the diabase magma by extreme differentiation.

Tyrrell,[2] in 1908, discusses Barlow's paper[3] on the origin of silver in James township, and Hore's paper on Cobalt.[4]

Knight and Bartlett,[5] in March, 1908, give the first description of the Keeley and Haileybury Silver (Frontier) mines in South Lorrain. There is an open cut 40 feet long and 14 feet deep, exposing a vein two to six inches wide on the Keeley. Smaltite and wire silver in what appear to be considerable quantity are present. At the Haileybury Silver claim a shaft had been sunk 40 feet on a vein which at the bottom showed five or six inches of smaltite and niccolite. The rock in the vicinity of the Keeley and Haileybury Silver veins belongs to the Keewatin series.

Coleman,[6] in 1908, comes to the conclusion that the basal conglomerates of the Lower Huronian (Cobalt series) of the Cobalt area are consolidated tillites or ancient boulder clays. This shows that a glacial period existed at that time. Specimens of striated pebbles have been found by him in the conglomerate.

Barlow,[7] in 1909, further discusses the veins in James township. He finds that while many of the veins or dikes are abruptly differentiated from the associated diabase, exhibiting perfectly sharp and in some cases free walls, others show a gradual transition from the vein material (pegmatite) into the surrounding diabase, which graduation can only be explained on the assumption of a commingling of material while both were in a fluid, or, at most, a viscous condition, and before complete solidification has taken place. Not only the native silver, but also the characteristic sulphides and arsenides began to be introduced along with the first pegmatite (aplite) filling. These metallics did not wait for the reopening of the pegmatite and the introduction of more abundant calcite, for the latter mineral accompanied and overlapped the crystallization of the feldspar. He considers the pegmatites to be the ore bringers.

The use of the terms "dike" and "vein" as separate names in regard to pegmatite is misleading. The strict limitation of their meaning has lead to certain misconceptions as to its manner of formation. He would prefer to make the two terms synonymous, or better still to use "vein" in both senses, for, accurately speaking, every "mineral vein" is intrusive in the surrounding country rock.

Tyrrell,[8] in 1909, discusses the origin of the mineral veins in the Montreal River area.

---

[1] Origin of the Cobalt-Silver Ores of Northern Ontario, by R. E. Hore, Jour. Can. Min. Inst., Vol. 11, 1908, pp. 275-286.

[2] Mineral Veins in the Montreal River District, by J. B. Tyrrell, Can. Min. Jour., Dec. 15, 1908, pp. 651a-652a.

[3] The Origin of the Silver of James Township, by Alfred E. Barlow, Jour. Can. Min. Inst., Vol. 11, 1908, pp. 256-273.

[4] Origin of Cobalt-Silver Ores of Northern Ontario, by R. E. Hore, Jour. Can. Min. Inst., Vol. 11, 1908, pp. 275-286.

[5] Cobalt-Silver Veins, South Lorrain, by Cyril W. Knight, Ont. Bur. Mines, Vol. XVI., 1907, pt. II, p. 147.

[6] The Lower Huronian Ice Age, by A. P. Coleman, Jour. Geol., Vol. 16, 1908, pp. 149-158.

[7] Mineral Veins in the Montreal River District, by Alfred E. Barlow, Can. Min. Jour., Jan. 15, 1909.

[8] Mineral Veins in the Montreal District, by J. B. Tyrrell, Can. Min. Jour., Mar. 1, 1909, p. 149.

Coleman,[1] in 1909, describes the Pleistocene geology in northeastern Ontario, with special reference to the Glacial lake Ojibway. Mention is made of the Pleistocene deposits along the Temiskaming and Northern Ontario railway.

Bowen,[2] in 1909, gives analyses of three aplite dikes from the Cobalt silver field and shows that the aplites have a simple mineral composition.

Collins,[3] in 1909, gives a preliminary report on Gowganda.

Bowen,[4] in 1909, describes the aplites and diabase of the Cobalt area.

Ramsay,[5] in 1909, gives a brief description of the rocks and veins in the Maple Mountain area.

Mickle,[6] in 1910, discusses the probable number of veins in the Cobalt district. At the close of July, 1907, there appeared to be in all sixty-six different productive veins. These were distributed among the geological formations as follows:—

Huronian (Cobalt series)........................	53
Diabase....................................	7
Keewatin....................................	6

Hore,[7] in 1910, discusses the diabase of the Cobalt area.

Hore,[8] in 1910, discusses the Huronian rocks of Nipissing, Ontario.

Collins,[9] in 1910, describes the quartz-diabase of Nipissing district.

Bowen,[10] in 1910, describes the diabase and granophyre of Gowganda. He ascribes the red and pink colour of the plagioclase to thin plates of hematite filling the cleavage spaces.

Wilson,[11] in 1910, reports on an area adjoining the east side of Lake Timiskaming, Quebec. He finds that the geology differs but slightly from the Timagami-Timiskaming area, presenting rocks of the same varieties and in the same stratigraphical relationship. He finds, however, no unconformity in the Huronian (Cobalt) series between the conglomerate and greywacké, and the overlying quartzite and arkose.

The diabase, with which the silver-cobalt ores of the Timiskaming area are associated, has its largest extent in the township of Fabre. This diabase is poorly exposed and prospecting is thus rendered difficult. No silver deposits of economic value have been found.

---

[1] Lake Ojibway, Last of the Great Glacial Lakes, by A. P. Coleman, Ont. Bur. Mines, Vol. XVIII, 1909, pp. 284-293.

[2] Composition of the Aplites, by N. L. Bowen, Can. Min. Jour., April 15, 1909, p. 240.

[3] Preliminary Report on Gowganda Mining Division, by W. H. Collins, Geol. Surv. Can., 1909, pp. 47.

[4] Diabase and Aplite of the Cobalt Silver Area, by N. L. Bowen, Jour. Can. Min. Inst., Vol. 12, 1909, pp. 517-528.

[5] The Maple Mountain Mining District of Ontario, by J. D. Ramsay, Can. Min. Jour., Sept. 1, 1909, pp. 526-527.

[6] The Probable Number of Veins in the Cobalt District, by Geo. R. Mickle, Jour. Can. Min. Inst., Vol. 13, 1910, pp. 325-335.

[7] Diabase of the Cobalt District, Ont., by R. E. Hore, Jour. Geol., Vol. 18, No. 3, April-May, 1910.

[8] Huronian Rocks of Nipissing, Ontario, by R. E. Hore, Jour Geol., Vol. 18, No. 5, July-Aug., 1910.

[9] Quartz-Diabase of Nipissing District, by W. H. Collins, Econ. Geol., Vol. 5, No. 6, Sept., 1910, pp. 538-550.

[10] Diabase and Granophyre of the Gowganda Lake District, Ont., by N. L. Bowen, Jour. Geol., Vol. 18, No. 7, Oct.-Nov., 1910, pp. 658-674.

[11] Geology of an Area Adjoining the East Side of Lake Timiskaming, Quebec, by Morley E. Wilson, Geol. Surv. Can., Publication No. 1064.

Coleman,[1] in 1910, summarizes again his reasons for believing that there was an ice age in Lower Huronian times. He notes that Willet G. Miller, in 1905, had guardedly suggested the resemblance of the conglomerate to boulder clay.[2]

Miller and Knight,[3] in 1911, discuss the Laurentian system.

Harvie,[4] in 1911, geologically maps and reports on the township of Fabre, Quebec, on the east side of Lake Timiskaming and opposite South Lorrain. He finds that the geological sequence in Fabre is very similar to that of Cobalt, but is fuller, since another Huronian series, not known at Cobalt, is present. This series he names the Fabre series. It is closely associated with the Keewatin, and also somewhat squeezed. It is a thin succession of conglomerate, arkose, quartzite, and greywacké, which represent the lowest series of Huronian found in the area. This series lies below and is essentially different from the Lower Huronian (Cobalt series) described by Miller at Cobalt. The relations to the Laurentian are not as well known, the sediments being older than some of the dike rocks and younger than others.

He finds that numerous cobalt-bearing quartz-calcite veins, with a few aplite dikes, are found in the diabase. None of these veins contain economic quantities of silver. A little gold occurs in the veins. Some of the veins have been found in the Keewatin, but none in the Huronian. He believes there is no great promise in the mineral deposits of Fabre.

Miller,[5] in 1911, proposes to employ the name Cobalt series for the fragmental series in which the cobalt-silver veins characteristically occur at Cobalt. The name Timiskaming will be used for the older, more disturbed conglomerate series which outcrops at Kirk and Cross lakes and in greater volume on Lake Timiskaming, outcrops also being known a considerable distance south of Cobalt and 90 miles to the northwest at Porcupine. The granite intruding in the Timiskaming series but not in the Cobalt series, will be called the Lorrain granite, a name under which it is already known. The quartz-diabase of the sill at Cobalt, which is of such great economic importance and is so widespread not only in that vicinity, but throughout a large territory in the district of Nipissing, will be called the Nipissing diabase. This will serve to distinguish it from diabase of other ages that occur in the region.

Miller finds that faults, generally with small displacement, and joints are very numerous in rocks in which the Cobalt ores are found. Few drifts are run that have not one smooth wall, indicating a fault or a joint for at least part of their course. The faults are of various ages. Some of those in the Keewatin are doubtless pre-Huronian in age. Others were formed at the time of the Lorrain granite intrusion; while later faulting took place at the time of the intrusion of the diabase sill and later still when the fissures now occupied by the ores were opened. After the filling of the veins, there was again faulting in pre-Cambrian times. A few veins occupy fault planes while others have been disturbed by more recent faulting. There were even minor faults that were formed after the glacial period.

---

[1] The Lower Huronian Ice Age, by A. P. Coleman, Internat. Geol. Congr., 1910.

[2] Ont. Bur. Mines, Vol. XIV, 1905, p. 41.

[3] The Laurentian System, by Willet G. Miller and Cyril W. Knight, Ont. Bur. Mines, Vol. XX, pt. I, pp. 280-284.

[4] Geology of Portion of Fabre Township, Pontiac County, by Robert Harvie, Mines Branch, Quebec, 1911. *See also* re Fabre series, Ont. Dept. Mines, No. 62, Vol. XIX, pt. II.

[5] Notes on the Cobalt Area, by Willet G. Miller, Eng. and Min. Jour., Sept. 30, 1911, pp. 645-649.

Hore,[1] in 1911, reviews the geology of the Cobalt area.

Hore,[2] in 1911, reviews the geology of Cobalt.

Hore,[3] in 1911, discusses differentiation in the quartz-diabase of the Cobalt area.

Mickle,[4] in 1912, estimates a probable total production of silver from Cobalt of 242 million ounces.

Up to July, 1911, there appeared to be 111 veins that could be considered productive; these were distributed among the geological formations as follows:—

Huronian (Cobalt series).........	86 veins, or 77.5 per cent.
Diabase.......................	12 veins, or 10.8 per cent.
Keewatin......................	13 veins, or 11.7 per cent.

The diabase has yielded 7 per cent., the Keewatin 10.85 per cent., and the Cobalt series 82 per cent. of the total production.

Knight,[5] in 1912, compiles ten cross-sections showing the structure of the rocks in the Cobalt area proper. He finds that the Cobalt lake fault has a vertical displacement of 233 feet at La Rose mine, while at the McKinley-Darragh it is possibly 400 feet or more.

Colvocoresses,[6] in 1912, finds at the Millerett mine that silver ore occurs in the No. 1 vein in the Huronian above the diabase sill. The top of the sill dips eastward at 30°.

He points out that in Gowganda all of the producing veins have been found in the diabase or (in one case) in the Huronian rocks above the diabase sill. Nothing has been found in the foot-wall of the diabase sill.

Very little prospecting has ever been done in the Huronian conglomerate, but he believes there is every reason to assume that some good conglomerate veins yet remain to be discovered. The Miller Lake-O'Brien vein in diabase had not a remarkable surface showing, nor did the mine look particularly promising until after a year's hard work.

Palmer and Bastin,[7] in 1913, in preliminary experiments show that certain sulphides and arsenides of copper and nickel, precipitate metallic silver very efficiently from dilute aqueous solutions of silver sulphate. The more common sulphides, such as pyrite, galena, and sphalerite, were relatively inactive as precipitants of silver from aqueous solutions of its sulphate.

Tyrrell,[8] in 1913, points out that as a general rule in South Lorrain the veins appear to be near the contact between the diabase and the Keewatin, either in the diabase itself or in the Keewatin greenstone. In South Lorrain the conglomerates do not appear to have been attractive to the silver-bearing solutions. The rich ore-bodies, where they occur, are not found directly at the diabase contact, but at some little distance away from it.

---

[1] Geology of the Cobalt District, Ont., Canada, by R. E. Hore, Trans. A.I.M.E., Vol. 42, 1911, pp. 480-499.

[2] The Silver Fields of Nipissing, by R. E. Hore, Jour. Can. Min. Inst., Vol. 14, 1911, pp. 612-636.

[3] Differentiation Products in Quartz-Diabase Masses of the Cobalt District, by R. E. Hore, Econ. Geol., Vol. 6, No. 1, 1911, pp. 51-59.

[4] The Probable Total Production of Silver from the Cobalt District, by Geo. R. Mickle, Jour. Can. Min. Inst., 1912.

[5] Recent Underground Development Work at Cobalt, by Cyril W. Knight, Trans. Can. Min. Inst., Vol. 15, 1912, pp. 231-237.

[6] Gowganda during 1911, by G. M. Colvocoresses, Can. Min. Jour., April 15, 1912, pp. 256-260.

[7] Metallic Minerals as Precipitants of Silver and Gold, by Chase Palmer and Edson S. Bastin, Econ. Geol., March, 1913.

[8] Silver Veins of South Lorrain, by J. B. Tyrrell, Can. Min. Jour., June 1, 1913, pp. 329-330.

Miller and Knight,[1] in 1913, referring to northern Ontario, are inclined to place the Keewatin jaspilite and other sediments associated with it, such as greywacké and crystalline limestone, with the Grenville series. They consider that the dual grouping of the pre-Cambrian should be discarded.

It is not at all unlikely that the diabase and norite of Cobalt and Sudbury, respectively, are of the same age as the Keweenawan basic igneous rocks of Michigan and the Lake Superior country generally.

Miller,[2] in 1913, summarizes the geology of the Cobalt area. This is largely a summary of Miller's fourth edition of his report on Cobalt.

Collins,[3] in 1913, divides the rocks in Gowganda into the following divisions:—

	Pleistocene		Unconsolidated glacial till, stratified clay and sand.
			Great unconformity.
PRE-CAMBRIAN	Post Huronian intrusions		Olivine diabase. Quartz diabase and aplite.
	Huronian	Upper or Middle.	Quartzite, arkose, and quartz conglomerate (Lorrain series).
			Faint unconformity.
		Middle or Lower.	Conglomerate, greywacké, slate, and arkose (Cobalt series).
			Rhyolite, lava and tuff.
			Great unconformity.
	Laurentian batholithic intrusions		Hornblende and biotite granites, granodiorite and syenite and their gneissic equivalents.
	Keewatin		Basic and acid volcanic and intrusive rocks, chloritic and sericitic schists, iron formation, graphitic slate and hornblende schist.

Collins finds that the silver deposits form veins, commonly less than a foot wide, either within the diabase or, in a few cases, in the formations immediately adjacent. These consist of a quartz and calcite, less frequently barite, gangue carrying native silver, smaltite, niccolite, chalcopyrite, and smaller amounts of native bismuth, argentite, galena, pyrite, specularite, and other minerals. Silver was deposited somewhat later than the other minerals and traverses them as a fine network. Erythrite and annabergite occur as oxidation products of smaltite and niccolite for a depth of a few feet beneath the surface. The ores are not evenly distributed through the veins, but occur, so far as present explorations indicate, in irregular masses. The diabase, for a few inches away from the veins, is often irregularly mineralized.

He regards the diabase masses as occurring in sills, and he gives an excellent description of their lithological character.

The aplite dikes which cut the diabase may be described as unusually fine-grained pink granite poor in dark minerals, but there are wide variations from such a type.

---

[1] Sudbury, Cobalt and Porcupine Geology, by Willet G. Miller and Cyril W. Knight, Eng. Min. Jour., June 7, 1913, pp. 1129-1133.

[2] Guide Book No. 7, Internat. Geol. Congr., 1913.

[3] Geology of Gowganda Mining Division, by W. H. Collins, Geol. Surv. Can., Memoir No. 33.

Miller,[1] in 1913, publishes the fourth edition of his report on the cobalt-nickel arsenides and silver deposits of Timiskaming. This work of 279 pages, with detailed geological surface maps and plans, is the outstanding report on the area. On account of its size it is not practical to attempt to summarize it here. The report gives an account of the discovery of the veins, a description of the ores and minerals, a record of the dividends paid, an account of the rocks and their age relationships, and so forth. The report is still in print and may be obtained from the Ontario Department of Mines, Toronto. For convenience, however, Miller's subdivisions of the rocks are given below, together with his broad general comments thereon. In the following legend, Miller discontinues the use of the term Huronian which he had made use of in the first three editions.

> The dual subdivision of the pre-Cambrian into Algonkian and Archean, or Proterozoic and Archeozoic, employed by many authors, is not adopted by the writer, since he believes that the Grenville series, which includes limestones and other sediments of great thickness, is of pre-Laurentian age. The thickness of the sediments in the Grenville and the character of the deposits make it inadvisable to attempt to subdivide the pre-Cambrian into an upper characteristically sedimentary group, above the Grenville, and a lower igneous complex including the Grenville sediments. The subdivision into Proterozoic and Archeozoic groups, the latter including the Grenville, is purely arbitrary. Thus a dual subdivision of pre-Cambrian rocks, based on arguments that have been employed in its behalf, fails. If a name is desired for the pre-Cambrian rocks, to correspond with Paleozoic and Mesozoic, the well-known name Eozoic may be used.

AGE RELATIONS OF ROCKS OF COBALT AND ADJACENT AREAS

PALEOZOIC	
SILURIAN Niagara	Prominent outcrops of Niagara limestone, with basal conglomerate and sandstone, occur on some of the islands and the shores of the north end of lake Temiskaming.
(Great unconformity)	
EOZOIC OR PRE-CAMBRIAN	
LATER DIKES	Aplite, diabase, basalt.
NIPISSING DIABASE *(Intrusive contact)*	This diabase, which is of such great interest in connection with the cobalt-silver veins, is believed to be of Keweenawan age. Certain aplite dikes are genetically connected with the diabase.
COBALT SERIES *(Unconformity)*	The Cobalt series includes conglomerate, greywacké and other fragmental rocks.
LORRAIN GRANITE *(Intrusive contact)*	This granite occupies a considerable part of the township of Lorrain and has large exposures elsewhere in the vicinity of lake Temiskaming.
LAMPROPHYRE DIKES *(Intrusive contact)*	Lamprophyre dikes are to be seen near some of the mines at Cobalt.
TEMISKAMING SERIES *(Unconformity)*	Like the Cobalt series, the Temiskaming consists of conglomerate and other fragmental rocks.
KEEWATIN COMPLEX	The Laurentian, gneiss and granite, which in age lies between the Keewatin and Temiskaming, is absent in the Cobalt area proper, but is found in the surrounding region. Under the heading Keewatin are grouped the most ancient rocks of the region. They consist essentially of basic volcanic types, now represented by schists and greenstones, together with more acidic types, such as quartz-porphyry. With the Keewatin are included certain sediments, such as iron formation or jaspilyte, dark slates and greywackés, which probably represent the Grenville series of southeastern Ontario. Certain dike rocks that are grouped with the Keewatin may be of post-Temiskaming age, but since they have not been found in contact with the Temiskaming their age relationships are unknown.

---

[1] The Cobalt-Nickel Arsenides and Silver Deposits of Timiskaming, by Willet G. Miller, Ont. Bur. Mines, Vol. XIX, pt. II, 1913.

Livermore,[1] in 1914, gives a description of the method and machinery used in draining Kerr lake, Cobalt.

Williams,[2] in 1915, determines from fossils collected that the dolomites west and north of Haileybury are of Black River age; that the upper strata of Mann island and the top of Farr island belong near the base of the Niagara; that the Dawson point section includes besides undetermined beds at the base, the Niagara from its base to the horizon of numerous corals; that Chief island contains in the patches of limestone resting upon the Huronian, representatives of both Niagara and Trenton rock; that a limited area of Silurian strata occurs north of the wharf at Haileybury; and that the green calcareous shales making up the lower part of the section at the northwestern end of Mann island and probably concealed by talus on the eastern side of Dawson point, must be between Black River and Niagara in age.

Miller and Knight,[3] in 1915, present a detailed classification of the pre-Cambrian ore deposits in the Province of Ontario, showing the various metallogenetic epochs into which the period may be divided. The following table shows that there have been at least four great metallogenetic epochs during the pre-Cambrian period in Ontario, namely, Grenville, Algoman, Animikean, and Keweenawan. A fifth epoch of minor importance should probably be added to represent the ore-bodies associated with the basic intrusives that preceded the intrusion of the Algoman granite and followed the deposition of the Timiskaming sediments.

The basic rocks of the Keweenawan in Michigan and in the Coppermine River country are considered to be genetically connected with deposits of native copper. In Ontario, along the north shore of Lake Huron, the Keweenawan intrusives appear to have given rise to the deposits of copper pyrites, while at Sudbury the copper-nickel ores and at Cobalt the silver-cobalt veins have been shown to be genetically connected with them.

AGE CLASSIFICATION OF ONTARIO ORE DEPOSITS

Keweenawan—Epoch, following basic intrusions, of (a) Silver, cobalt, nickel and arsenic at Cobalt and elsewhere, (b) Nickel and copper at Sudbury, and copper elsewhere. Certain gold deposits, not now productive, appear to belong to this epoch.

Animikean—Epoch of deposition of "iron formation" as a chemical precipitate.

Algoman—Epoch, following granite intrusions, of gold at Porcupine and at many other localities, and of auriferous mispickel. Deposits of galena, zinc blende, fluorite and other minerals also appear to have been derived from the granites, but some of them were not formed till post pre-Cambrian time. Preceding the intrusion of the Algoman granites, basic intrusives, that appear to be of post-Timiskamian age, gave rise to nickel and titaniferous and non-titaniferous magnetite deposits and chromite.

Timiskamian—Epoch of minor deposition of "iron formation" as a chemical precipitate.

Laurentian—Granite intrusions probably gave rise to ore deposits which have been removed by excessive erosion as is known to be the case with deposits of later origin.

Loganian:—

- *Grenville*—Epoch of deposition of extensive "iron formation" as a chemical precipitate among other sediments.
- *Keewatin*—Composed largely of basic volcanic rocks.

Miller and Knight,[4] in 1915, give a general discussion of the pre-Cambrian geology of Ontario and of the classification. They divide the rocks into the following subdivisions:—

---

[1] Draining Kerr Lake, by R. Livermore, Trans. A.I.M.E., Vol. 49, 1914, pp. 328-342.

[2] The Ordovician Rocks of Lake Timiskaming, by M. Y. Williams, Geol. Surv. Can., Mus. Bull. No. 17.

[3] Metallogenetic Epochs in the Pre-Cambrian of Ontario, by Willet G. Miller and Cyril W. Knight, Trans. Roy. Soc. Can., Ser. III, 1915, Vol. IX.

[4] Revision of Pre-Cambrian Classification in Ontario, by Willet G. Miller and Cyril W. Knight, Jour. Geol., Vol. 23, 1915, No. 7, Oct.-Nov.

PRE-CAMBRIAN

KEWEENAWAN	
Unconformity	
ANIMIKEAN	Under this heading the authors place not only the rocks that have heretofore been called Animikie, but the so-called Huronian rocks of the "classic" Lake Huron area, and the Cobalt and Ramsay Lake series. Minor unconformities occur within the Animikean.
Great unconformity	
(ALGOMAN granite and gneiss) *Igneous contact*	Laurentian of some authors, and the Lorrain granite of Cobalt, and the Killarney granite of Lake Huron, etc.
TIMISKAMIAN	In this group the authors place sedimentary rocks of various localities, that heretofore have been called Huronian, and the Sudbury series of Coleman.
Great unconformity	There is no evidence that this unconformity is of lesser magnitude than that beneath the Animikean.
(LAURENTIAN granite and gneiss)	
Igneous contact	
LOGANIAN: Grenville (*Sedimentary*) Keewatin (*Igneous*)	The authors have found the Keewatin to occur in considerable volume in southeastern Ontario and have determined the relations of the Grenville to it.

Hume,[1] in 1916, maps an area of Paleozoic sediments extending from the north end of Lake Timiskaming northward to Englehart. The chief change in the geological map of the area was made in the region extending northwest from New Liskeard; this part had previously been mapped as pre-Cambrian, but from drill records available it was found that the rock is Paleozoic limestone, Lockport in age. He finds that the Paleozoic rocks may be subdivided as follows:—

> Lockport and Cataract formations, Silurian in age, including some basal conglomerate and sandstone of Ordovician age.
> Black River—Trenton, Ordovician in age.

Reference is made to the Lake Timiskaming fault.

Ellsworth,[2] in 1916, makes a chemical study, combined with a microscopic examination of polished surfaces of certain minerals from Cobalt. He identifies four new minerals, namely, löllingite, rammelsbergite, chalcocite, and symplesite. He finds the order of deposition of the minerals to agree in the main with the conclusion reached by W. G. Miller and C. W. Knight.

From the numerous extremely intimate intergrowths which have been observed among the Cobalt minerals, e.g., smaltite-chloanthite, niccolite-breithauptite, etc., he believes that certain of these minerals were precipitated in greater or less quantity at the same time.

> The structures observed appear to indicate that the mineralizing solutions at first were relatively very rich in arsenic and during this time intergrowths of diarsenides—smaltite and chloanthite—were chiefly precipitated. The arsenic content of the solutions gradually diminished and monarsenides—niccolite and breithauptite—were for a time predominately deposited. The arsenic continued to decrease in amount and sulphur became prominent, so that sulpharsenides, such as cobaltite and arsenopyrite, were deposited. Finally, the arsenic in solution was reduced to a very small quantity, and calcite was deposited. A period of fracturing ensued and the solution which may now have been of either a sulphate or carbonate character circulated through the fractured veins. From this solution native silver and argentite were precipitated by the action of arsenides and calcite.
>
> It is believed that the process of deposition of the various arsenides and sulpharsenides was more or less continuous, and that, though a period of maximum deposition for any one of these minerals may be distinguished, there is, nevertheless, no sharp dividing line between the different periods.

---

[1] Paleozoic Rocks of Lake Timiskaming Area, by G. S. Hume, Sum. Rept., Geol. Surv. Can., 1916, pp. 188-192.

[2] A Study of Certain Minerals from Cobalt, Ontario, by H. V. Ellsworth, Ont. Bur. Mines, Vol. XXV, pt. I, 1916.

The apparent order of deposition from the writer's observations may be indicated in tabular form as follows:—

I. Arsenides and Sulpharsenides	1. Diarsenides	$NiAs_2$ $CoAs_2$
	2. Monarsenides	$NiSb$ $NiAs$
	3. Sulpharsenides	$CoAsS$ $FeAsS$

II. Calcite, followed by fracturing.
III. Native silver and argentite, native bismuth, sulphides and sulpho-salts.
IV. Decomposition products—arsenates of cobalt, nickel, iron, copper, and calcium.

Whitman,[1] in 1916, after a close study of many of the underground workings at Cobalt, concludes:—

That the ore bodies in the Huronian lie wholly within it and chiefly near the base.

That the ore bodies in the Keewatin lie chiefly within 300 feet of the upper or lower contact of the diabase.

That the ore bodies in the diabase lie chiefly within 300 feet of its margins.

Faults.—That ore exists in all classes of faults of steep attitude, but is distributed in them according to their attitudes and the stresses extant during the period of deposition.

That ore bodies of importance were often formed in favourable fractures in the walls of faults paralleling or diverging from them.

That such faults are genetically related to the folds in the district, striking diagonally across them from east to west, or approximately paralleling their axes.

Folds.—That ore is to be found in economic quantities only in areas of strong folding.

That within such areas the most favourable sites for ore are the slopes of folds, and particularly the steeper ones.

That on these slopes the most favourable spots are minor folds, and that the most favourable of these are the small cross folds.

That veins in these situations tend to parallel the dips of the sides of those minor folds being influenced by the major ones similarly but to a less extent, or that the veins tend to cross the axes of the minor folds, save as they may tend to parallel the axes of certain minor anticlines or to parallel faults.

That these sites are the best for ore bodies, particularly when they are associated with contacts as discussed above, or with major faults.

That the slopes are better sites than the axes of major folds, because on the slopes the deformation is the greatest and the best opportunities are afforded for the circulation and deposition of ore materials; and for the same reasons the steeper slopes are the better.

Joints.—That the fractures in which the ore bodies were formed were chiefly vertical joints produced by the compressive stresses which produced the folds and faults.

That such structural planes of weakness as contacts, slate beds, and major faults, together with the slopes of folds, constitute loci of strain and maximum jointing; and in such regions, particularly where two or more of them coincide, the vertical joints will have been converted into ore bodies.

That the joints in the Huronian are the most favourable seats of deposition, those in the diabase next, and those in the Keewatin least.

That the joints now open and uncemented express chiefly the final relief of the rocks from the original deformative stresses.

That the veins were formed under conditions of too great pressure for the existence of large open spaces or for the free opening of small fractures, and that they were formed by the metasomatic replacement of the walls of tight fractures.

Attitudes of Channels.—That of veins formed in joints, those that are the steeper are the richer, and the most flatly inclined are the poorer, under otherwise similar conditions, the richness being proportional to the degree of the dip, and the veins being thus classifiable with regard to both dip and contents:—

10° to 30°—Quartz, calcite, little sulphide.
30° to 50°—Quartz, calcite, much sulphide, little arsenide, trace of silver.
50° to 70°—No quartz, calcite, little sulphide, much arsenide, notable silver.
70° to 90°—No quartz, calcite, no sulphide, much arsenide, much silver.

That faults are not good seats of deposition for these ores, and that of faults with narrow shear zones the steeper side-thrust faults are most favourable, and in the wide shear zones of other faults, ores have formed only in spots locally relieved of compressive stress.

FAULTS

That the faults are all due to compression or to folding torsion.

That the east-west faults are side thrusts.

That the other faults are upthrusts or down thrusts.

That faults along folding axes on a given horizon dip with those axes.

---

[1] Final General Geological Report on the Area about Cobalt Lake, by Alfred R. Whitman, unpublished report, dated 1916.

That the side thrusts were the first faults, usually preceding the folding, that the folding torsion faults were next in age, and that the thrusts on the axial planes of folds were the last, but that the folding continues through all the faulting and after it, and the mineralization followed all the deformation

Whitman considers that discussion of the Keewatin-Huronian contact would not be complete without a description of its contour and its configuration in relation to the folds of the district.

On beginning his work, Whitman found that the contact between the Keewatin and Huronian was irregular and that some of the irregularities were abrupt. Some of the mine managers referred to Keewatin hills and valleys underlying the Huronian. There seemed to be an interesting prospect that the productive conglomerate could be forecast beneath the diabase in certain spots through the careful working out of old drainage systems carved in the Keewatin surface, in which Huronian gravels and finer sediments had been deposited.

Investigations were immediately started along this line; but it soon began to appear that the theory was untenable. The fact that the dips of the finer sediments conformed with the contact was at first admitted as consistent with the supposition that the first layers of sediment in a body of water would necessarily conform precisely with the sloping floor of the basin. However, it was recognized that this parallelism was not confined to the fine sediments lying on the Keewatin floor, but was also shared by those 100 feet or more above it, and by coarse boulder layers as well. These facts obviously could not be reconciled, and the idea of folding was adopted and subsequently proven.

The evidences in favour of folding are: (1) The interbedding of fine sediments with thick layers of heavy boulders, and the parallelism of the whole series to the contact for a distance of 100 feet and more from it. (2) The development of joints in the sediments as well as in the Keewatin and the diabase, parallel to the Keewatin-Huronian contact and showing evidences of shear in the direction of upthrust faulting on the sides of undulations. These flat-lying shear joints in many cases can be seen passing through pebbles in the Huronian conglomerate and faulting them short distances. Also in many cases these joints show distinct striae paralleling their dip. (3) Shearing on the contact itself.

The inference from this conformity of bedding with the contact is that the contact was virtually a horizontal plane when the sediments were laid down. And this by long careful research has been found to be the remarkable fact. There are a few exceptions to this rule: one of them is a small depression, perhaps 100 feet long by 150 feet wide and 25 feet in depth, lying on the west side of the Coniagas mine about one-third of the way from the north corner to the south corner. Another depression of about the same depth apparently exists in the Seneca Superior mine under Cart lake. A corresponding promontory of similar height lies along the brow of Nipissing hill above the north end of the higher tailings dam.

A few other minor irregularities in this old land surface have been noted; but for all purposes significant to mining operations, the surface may be assumed to have been originally a nearly smooth flat surface folded only after the advent of the diabase.

Bastin,[1] in 1917, after making an examination of the Cobalt ores with the microscope, applies the theory of enrichment by descending surface solutions to account for the rich silver ores of Cobalt.

---

[1] Significant Mineralogical Relations of the Silver Ores of Cobalt, by Edson S. Bastin, Econ. Geol., April-May, 1917.

Collins,[1] in 1917, finds that the Huronian in the Onaping and Gowganda areas consists of a single series—the Cobalt series. It is composed of conglomerate, greywacké, quartzite, and one thin formation of siliceous limestone. It is separable into two quite distinct parts. The lower part is made up dominantly of dark grey conglomerates and greywackés regarded as probably of glacial origin. For this lower part he suggests the name Gowganda formation, as the rocks are exceptionally well developed in the Gowganda area. The upper part of the series is thick and consists of quartzite, the lower part of which is called the Lorrain quartzite.

In spite of their diversity of appearance, composition, and genesis, these two parts of the Cobalt series are largely in conformable relation to each other. An unconformity exists in a few places.

Reid,[2] in 1918, reviews Bastin's paper[3] in which Bastin regards the silver ores of Cobalt as secondary in origin.

Reid believes that the theory of secondary enrichment is inapplicable to the Cobalt deposits, owing to the slight apparent relation of the ore-shoots to the surface as indicated by the absence of the zones of oxidation and of primary ore or protore—two of the most important criteria for the recognition of secondary deposits. The silver veins in their origin are related primarily to the diabase intrusion, and secondarily to various structural conditions in its neighbourhood, to wit, areas of local differential fracturing around the borders of the intrusive body, probably caused by compressive stresses. This fracturing, and especially the attendant mineralization, is local in character and does not extend beyond the contact area; it is due to the relative frangibility and permeability of the rocks involved. In this relationship the conglomerate takes the first place, diabase the second, and Keewatin the third. The enriching solutions are considered to be deep seated in origin, being connected with the diabase magma and consequently alkaline in reaction, the silver being probably carried in carbonate solution.[4]

Whitehead,[5] in 1920, comes to the conclusion that the Cobalt series is of normal stream origin. Striated pebbles, which have been mentioned as an indication of the glacial origin of these strata, were found during the investigation, but are believed to have been crushed by the dynamic deformation of the rocks. The parts of the basal conglomerate resembling residual soil and breccia, the well-sorted character of many beds, and the usual stratification, unite to offer proof of fluviatile origin.

Faults.—The faults of the area are all reverse faults. The familiar dip-slip fault is the usual form, but displacement is often principally lateral.

By far the greatest number of ore-shoots in the district are determined, however, by flat-dipping shear zones or faults. Such faults lie in many places in a zone of movement upon and near the Huronian-Keewatin contact. Similar planes of movement, deflected from this contact by irregularities, primary or due to folding or faulting, lie partly in the Huronian sediments, or, where formed with no relation in the contact, lie wholly in these sediments. Other contacts, as those of the diabase and Keewatin, and of the diabase and Huronian, are loci of similar movement, and such shear zones may lie also within the diabase. Where faults are distributive on the bedding of slates, great masses of low-grade ore have been formed near veins. Above the contact or near a fault plane, which is usually heavily mineralized by calcite, fan-shaped ore-shoots lie in the vein and possess typical peripheral mineral variations. Nearest the fault the vein contains predominantly smaltite, often with dull silver-gray cores of a mineral, probably cobaltite. Away from the ore-centre, niccolite cores in smaltite spherules are encountered, and transition takes place in turn between these spherules into massive niccolite. At the periphery sparsely disseminated niccolite or smaltite spherules pass into pure calcite of pinkish colour. Silver content decreases gradually but surely from the central axis, near the fault, to the periphery of the shoot.

---

[1] Onaping Map Area, by W. H. Collins, Geol. Surv. Can., Memoir No. 95, 1917.

[2] J. A. Reid, Econ. Geol., July, 1918.

[3] Significant Mineralogical Relations of the Silver Ores of Cobalt, by Edson S. Bastin, Econ. Geol., April-May, 1917.

[4] This summary was especially written by Mr. Reid for this report.

[5] The Veins of Cobalt, Ontario, by W. L. Whitehead, Econ. Geol., Vol. 16, No. 2, March, 1920.

Such ore-shoots have been developed in their lower portions 1,000 feet or more laterally, and have extended from 250 to 300 feet vertically. Many do not outcrop; indeed their upper portions are often 300 feet or more below the surface, and smaltite with native silver has been found 1,600 feet in depth at the Beaver mine.

He reaches the conclusion that downward secondary enrichment has been essentially absent as a factor in the deposition in the Cobalt ores and that silver of the veins is due to the last stage of the primary mineralization.

He gives the following summary of his work:—

GEOLOGY

1. The Cobalt series is of stream origin.
2. Its base was a topography of slight relief.

STRUCTURE

1. The rocks of the district were subjected to deformation by forces of compression upon two normal axes.
2. The structures developed are essentially contemporaneous.
3. The major fractures of economic importance were formed in definite relation to faults and folds.
4. These fractures were probably due to local tensional stress.

VEINS

1. The veins are but slightly faulted, and are about of the same age.
2. They may be classified by
    (*a*) Attitude,
    (*b*) Certain structures determining ore-shoots.
3. The mineral content is influenced by the type of joint on which the vein was formed.
4. The veins are predominantly due to replacement.
5. During an early hypogene stage calcite, dolomite, arsenides and sulphides were deposited.
6. During a late hypogene stage silver was deposited.
7. Supergene silver deposition is essentially absent from the veins.
8. The veins were probably formed by hot waters, of deep seated, possibly magmatic, origin.

Burrows,[1] in 1920, publishes his third report on Gowganda, the two previous reports forming part of Miller's report on Cobalt. The third report deals mainly with recent developments in Gowganda, particularly in the vicinity of Miller lake. He finds the rocks in general similar to those at Cobalt.

Hume,[2] in 1920, describes the Paleozoic rocks north of Lake Timiskaming and gives an account of the Lake Timiskaming fault. His views regarding the fault are summed up in Chapter I.

Whitman,[3] in 1920, comes to the conclusion that:—

1. The cobalt-nickel-silver ores of the Cobalt district were derived by diffusion and metasomatic fixation from the sill of Nipissing diabase with which they are associated.
2. They were deposited essentially in their present form below the groundwater level, not by circulating solutions, but by migrant ions traversing virtually stagnant or slowly circulating aqueous solutions, from all parts of the adjacent diabase, to such favourable seats of deposition as were accessible in the neighbourhood of its margins.

---

[1] Gowganda Silver Area, by A. G. Burrows, Ont. Dept. Mines, Vol. XXIX, pt. III, 1920, pp. 77-88.

[2] Am. Jour. Sci., 4th ser., Vol. 50, 1920, pp. 293-309.

[3] Diffusion in Vein-Genesis at Cobalt, by Alfred R. Whitman, Econ. Geol., Vol. 15, No. 2, March, 1920.

> 3. Mineral-laden water filled all the pores, joints, and fractures of the diabase and its neighbouring rocks; and through it moved the ions of vein material, at a temperature considerably below the melting point of the diabase, and at a pressure of several thousand feet of hydrostatic head. These ions were not capable of combination and precipitation without the help of an external agency; this consisted in catalytic influences or obscure metasomatic reactions of a kind which could take place only in rock relatively free from stress in one direction, as that must have been, which lined the sides of vertical tension joints lying parallel with the chief lateral stresses of the locality. The effect of these reactions of replacement, although virtually grain-for-grain as is understood by the term *metasomatic,* was to send into solution the aluminous and ferrous silicates composing the wall rocks, and to fill the vacated space grain-for-grain as it developed, with the ore minerals. The first rock to be thus replaced was that under least stress on the immediate walls of the indicated joints. The joints being tight, there was virtually no opportunity for crustification. The replacement extended outward from the plane of its inception, the widening vein always being so firmly frozen to its walls that aqueous solutions would move along it often with less ease than elsewhere through the wall rock.

Miller and Knight,[1] in 1920, propose to employ the name Haileyburian for intrusive dikes and other masses of lamprophyre and peridotite which are post-Timiskaming and pre-Algoman in age. The name is taken from that of the capital of the District of Timiskaming, the town of Haileybury. The following table shows the position of the Haileyburian rocks:—

PRE-CAMBRIAN EPOCHS OF ONTARIO AND THEIR METAL PRODUCTION

(*Keweenawan*).—Epoch, following basic intrusions, of (*a*) silver, cobalt, nickel, and arsenic at Cobalt and elsewhere; (*b*) nickel and copper at Sudbury, and copper elsewhere. Certain gold deposits, not now productive, appear to belong to this epoch.

Animikean.—Epoch of deposition of "iron formation" as a chemical precipitate. Includes the Cobalt and other series of sediments.

(*Algoman*).—Epoch, following granite intrusions, of gold at Porcupine and at many other localities, and of auriferous mispickel. Deposits of galena, zinc blende, fluorite, and other minerals appear also to have been derived from the granites, but some of them were not formed till post pre-Cambrian time.

(*Haileyburian*).—Preceding the intrusion of the Algoman granites, basic intrusives, of post-Timiskaming age, gave rise to nickel and titaniferous and non-titaniferous magnetite deposits and chromite.

Timiskamian.—Epoch of minor deposition of "iron formation" as a chemical precipitate, with conglomerate and other sediments.

(*Laurentian*).—Granite intrusions probably gave rise to ore deposits which have been removed by excessive erosion as is known to be the case with deposits of later origin.

Loganian....	*Grenville.*—Epoch of deposition of extensive "iron formation" as a chemical precipitate, with limestone and other sediments.
	(*Keewatin*).—Composed largely of basic lava flows, many of which are now schistose. There are also acid lava flows such as rhyolite.

Walker,[2] in 1921, thinks it probable that the material commonly called dyscrasite in Cobalt is made up of a eutectic intergrowth of silver and an antimonide of silver, probably Ag_3 Sb, which should contain 27.1 per cent. of antimony.

Bell,[3] in 1922, describes the geology and silver deposits of South Lorrain with special remarks about the Keeley mine. He has the following remarks to make regarding the oxidation of Wood's vein:—

> While most of the veins which have been prospected on the Keeley mines property show only superficial oxidation, Nos. 1 and 2 veins in the northern part of the property are slightly oxidized to a depth of 120 feet, and the southern portion of Wood's vein shows intense oxidation to the greatest depth yet attained (420 feet), a condition, as far as is known unique in the Cobalt district. The northern limit of oxidation on Wood's vein, which is quite abruptly demarcated, pitches steeply northward to about 350 feet, and from that depth to the deepest horizon of the

---

[1] Haileyburian Intrusive Rocks, by Willet G. Miller and Cyril W. Knight, Ont. Dept. Mines, Vol. XXIX, pt. I, 1920, pp. 235-236; Can. Min. Jour., Aug. 13, 1920.

[2] Dyscrasite from Cobalt, Ont., by T. L. Walker, University of Toronto Studies, Geological Series No. 12, pp. 20-22.

[3] The Occurrence of Silver Ores in South Lorrain, by J. Mackintosh Bell, Bull. Inst. Min. and Met., Feb., 1922.

mine (420 feet) deeply southward. Not only is Wood's vein itself oxidized, but the oxidation extends into the footwall for an unknown distance, and the branching stringers on the hanging-wall connecting the parent vein with No. 6 show a similar change. It is obvious that such extensive oxidation, even along so strong a line of fracturing, cannot be post-glacial, but must have ante-dated the glacial epoch. The greater depth to which oxidation extends in the southern than in the northern part of Wood's vein is probably to be connected with the influence on the parent vein and its numerous branches of the position of the water-level in a pre-glacial topography, the nature of which is not now clear. It seems possible that glacial denudation was not as great in South Lorrain generally as at Cobalt, and that in the southern and particularly narrow part of the depression occupied by Wood's vein protection against corrosion was given by the walls of greenstone on either side, especially after the depression had been filled by debris with the initial advance of the ice.

(1) Generally speaking, the richest and most persistent ore-shoots occur at or near the diabase-Keewatin contact, either within the diabase or within the Keewatin; the immediate contact is commonly barren or of low grade.

(2) An ore-shoot in the Keewatin does not ordinarily persist down into the diabase; or, vice versa, one in the diabase extend upward into the Keewatin. In other words, one part of a vein may carry ore in diabase, another in Keewatin.

(3) Gently inclined fractures, parallel to the contact and transverse to the dip of the veins, have an enriching effect upon the vein material.

(4) The junction of one vein with another, even a considerable distance from the contact, affects the values either in one vein or the other, or in both. If the veins are valueless before joining, a shoot of greater or less length is commonly made in the united vein.

(5) The values of a vein within sufficient distance of the contact, even in the smaller veins, are likely to improve when the vein occurs in a well-fractured zone, with cracking developed parallel to its strike.

(6) Ore-shoots are frequently localized on a main vein between the points of departure of two minor branching veins, or between the points of crossing of two zones of fracturing.

(7) When the ore-shoots are in Keewatin rocks, the most favourable type is an extremely dense fissile well-fractured greenstone. Lamprophyre is generally much less favourable, though some of the richest ore is found in fault planes when greenstone occupies one wall and lamprophyre the other.

(8) Generally speaking, the veins are more likely to carry ore when the dip of the vein is steep (upwards of 70 degrees) than when it is flat. Wood's vein, however, carries large amounts of ore when the dip is as low as 60 degrees, or even less.

The oxidized zone in Wood's vein reaches its northern-most extension in the mine workings at a depth of about 350 feet. On the surface, the outcrop of the vein occupies, as previously indicated, a relatively deep depression filled with boulder clay, and the vein has been exposed northward of the portion so heavily oxidized below ground. Whether oxidized material actually now occurs in this northern part of the vein or not, seems unimportant as compared with the certainty that it was oxidized in harmony with the vein farther south, though not to the same extent prior to glaciation.

The very rusty character of the veinstone, showing the presence of abundant iron in the ferric condition, indicates its derivation from pyrite or some iron-bearing sulphide, such as chalcopyrite, both of which are common in the unoxidized portions of the vein.

It is easy to understand how acidic ferric sulphate solutions, carrying their burden of silver leached from Wood's vein, seeped down its broad crushed zone into transverse veins below the hanging-wall (such as No. 16), where under changed chemical conditions the native silver was redeposited, and, on similar reasoning, how the ore-shoots of the northern upper unoxidized portions of Wood's vein were enriched by silver derived from the leaching of still higher sections of the vein, much of which may long since have been removed by erosion.

The fact that the southern oxidized portion of Wood's vein carries considerable silver ore from the surface downward to about 250 feet and is barren, or at least very low-grade, below that depth to the lowest horizon reached (420 feet), is explained by the super-saturation of solutions with oxygen, though the oxidation of all available sulphides near the surface, and the consequent necessity of reprecipitation of at least a certain portion of the silver dissolved, in accordance with the required state of chemical equilibrium. The relatively large amount of silver in the upper oxidized portion of Wood's vein has been derived from the eroded parts of the vein, and the enriched "gossan" has migrated downward with the progress of weathering, following the recognized rules of surface enrichment, except inasmuch as there was drastic erosion during glacial times. The barrenness of the oxidized zone in depth follows logically the assumption that at these inferior horizons there was originally sufficient sulphide present to satisfy the requirements of such oxygen as penetrated with surface waters to those depths, and that thus an acidic sulphate solution was again produced to carry the silver downward, leaving behind vein-material practically leached of all its values. It is noteworthy to mention that the silver in the oxidized surface-enriched ore is mainly in the native form, while that in what is considered to be largely secondarily-enriched ore below the oxidized zone is chiefly argentite, ruby silver, and stromeyerite, with less conspicuous native silver, generally in the wire form. In this secondarily-enriched ore, marcasite is invariably present and is especially conspicuous in the typical example of enrichment in No. 16 vein (420 feet).

The writer's opinion, it may be said in conclusion, is that while the primary silver-bearing material, including much of the high-grade ore, either in all of the veins near the diabase-Keewatin contact, or relatively remote therefrom, in Wood's vein, where structural conditions determining its deposition were present, is due to hypogene agencies, there has been widespread enrichment by descending solutions, which has materially changed the primary mineralization.

Bell,[1] in 1922, reviews the early history of South Lorrain, and gives a summary of the geology.

Knight,[2] in 1922, gives a brief account of the work, carried on in 1920 and 1921, during a geological survey of the underground workings of Cobalt and South Lorrain:—

> In making the resurvey, the broad general principles of structure which were worked out by Miller in the early days of the camp were found to be correct; but extensive mining operations, carried on since Miller's last report was published, have revealed certain structures of great economic importance. These structures and their relationships to ore-shoots could not be recognized and understood until mining operations had advanced beyond the stage reached at the time Miller's last report was issued.
>
> One of the most important structures regarding the ore-bodies is the general occurrence of the silver ore-shoots at and near contacts. The mine operators have found, for instance, that the silver occurs largely at and near the base of the Cobalt series, along the contact with the underlying Keewatin rocks. It has been shown that the silver ore-shoots seldom rise more than 150 or 200 feet above this contact, although the veins themselves, consisting mainly of calcite, do rise in many instances higher than this.
>
> Mining operations in recent years have gradually demonstrated that certain faults appear to limit, to some extent at any rate, the area in which productive veins occur. These faults are older than the ore-bodies. The outstanding example of such a fault occurs at the northern end of the Cobalt camp. This fault, which is a normal one with a displacement of from 4 to about 25 feet, strikes east 22 degrees south and dips to the southwest 70 to 90 degrees. It is a remarkable fact that north of the fault in the Cobalt area proper practically no high-grade ore has been found and only about 200,000 ounces of milling ore has been discovered. The fault itself contained important quantities of hi h-grade silver ore, both in the Hudson Bay and Nipissing mines; in the latter the vein was 26 inches wide in places.

He suggests that such faults as this have acted as dams, or impermeable barriers, through which, on account of the clay gouge in the fault, the solutions carrying the silver were not able to penetrate to any important extent.

Whitman,[3] in 1922, concludes that:—

> The fissures in which the ores were deposited were not cooling cracks in the strict sense, but were joints developed as a result of folding subsequent to the solidification of the diabase, and that the ores were derived from the diabase sheet itself, transported, and deposited chiefly through the agency of diffusion through relatively stagnant water in the pore spaces of the rocks.
>
> The folds, which affect diabase and sediments alike, are parallel with the major structural axes of the region and also with the original undulations of the diabase sheet which transgress the sedimentary beds, these folds being indicated in the diabase by innumerable large and small surfaces of shearing parallel with the surface of folding. The vein joints are spatially related to the folds and to the faults which originated during the folding. From these relationships it is inferred that such joints are genetically related to the other deformations, and to external compressive stresses rather than to direct cooling shrinkage. It is immaterial, and impossible to conjecture, whether this compressive stress arose chiefly from the lateral expansive force due to the heating of the locality of the sheet, or whether it arose chiefly from the general contraction due to the cooling of the locality of the sheet, the latter having an undulating configuration, and the undulations being weak to lateral compression resulting from the contraction of their general environment. Since all the deformations, however, are clearly of the same immediate period as those in the diabase, the conclusion seems inevitable that the diastrophic activity followed the solidification of the igneous mass, and was of a compressive character.
>
> In connection with the genesis of the ores it was pointed out that the commercial veins of the whole region as well as those in other parts of northern Ontario lie exclusively within marginal zones of the Nipissing diabase extending not more than 350 feet inward and outward in the diabase and Keewatin formations, nor more than 550 feet from the diabase margins in the Cobalt series of sediments. Even the noncommercial deposits and traces of cobalt in the northern part of the province are clearly related to the diabase, and no occurrences are known in this whole region that are clearly related to deep fissures in controversion of this rule. These facts are taken as strong evidence that the visible diabase itself was the source of the ores.

---

[1] Discussion on the Occurrence of Silver Ores in South Lorrain, Ont., Can., by J. Mackintosh Bell, E. T. McCarthy, H. F. Collins, J. A. L. Henderson, and R. T. Hancock; Bulletin 8, Inst. Min. and Met., Mar., 1922, pp. 1-14.

[2] Cobalt—Its Past and Future, by Cyril W. Knight, Eng. Min. Jour., May 6, 1922.

[3] Genesis of the Ores of the Cobalt District, Ont., Can., by Alfred R. Whitman, University of California Publications, May 31, 1922.

Negation was resorted to in order to exclude any supposition that the ores might have originated either through the downward circulation of vadose waters or through the upward circulation of juvenile or of hot meteoric waters. These matters need not, perhaps, be reviewed here further than to recall that the principal points made in regard to ascending solutions were: (1) that the heated mineral waters of the earth, whatever their origin, are known to be very dilute, so that large volumes would be required to pass through the rock in order to produce a moderate amount of metasomatic ore; (2) that in the absence of crustification and comb structure, metasomatic veins can be supposed to have grown only by marginal accretion; (3) that the chief circulation of underground water must be through fissures, and that its passage in volume through pore spaces must be practically inhibited by the large coefficient of friction due to the narrowness of the capillary and subcapillary openings and the tortuousness of its course; and (4) that, at least in the case of the silver ores under discussion, the veins and vein walls offer no more porous courses for the passage of water than the country rock offers, and therefore there would be no directive agency to cause mineral-bearing solutions to circulate there rather than at random through the country rock.

At Cobalt the chief ore production has come from beneath the diabase sheet, the veins being metasomatic replacements of the walls of *cul de sac* fractures. It seems far-fetched to suppose, since the diabase invaded chloritic schists which must have been saturated with ground water, that mineral-bearing solutions could have circulated downward from the diabase into the already saturated country rock in sufficient quantity and strength to have produced such metasomatic deposits in those blind fractures. Local convection currents could be supposed to have only gone round and round in a fracture of that sort without any chance of replenishing their original supply of mineral.

Water circulation being practically inhibited, recourse must be had to the principle of diffusion to explain the transference and deposition of mineral; but slow as would be the migration of metalliferous ions through the pore spaces of the rock, it would nevertheless be that of mineral at 100 per cent. concentration; and, furthermore, it would be directed from the point of its origin to the point of deposition by the steepening of the diffusion gradient at the point where precipitation is going on.

Time seems to be the chief obstacle in the way of accepting diffusion as a dominant agency in the genesis of metasomatic ore deposits. The ratio of its effectiveness to that of water circulation is the point in doubt. There are two forces which may be considered as tending to actuate the circulation of water through the pore spaces of rock, capillarity and hydrostatic head, or difference in head. Capillarity operates only in the first wetting of the rock; after that hydrostatic head is the sole actuator. In the depths this can arise only from heat or the compression of rocks containing water in sufficient quantity to be squeezed out. In either case the head would have to be considerable to drive water through capillary openings for a great distance; and the propagation of that force would be so slow that the passage of large volumes of water past a certain point within a firm rock might easily take as much time as the migration, by diffusion, of an equivalent amount of mineral ions. This ratio of effectiveness is at present indeterminable, and must await the results of experimentation. In the meantime, however, we have some very definite chemical facts in which to find assurance that diffusion is a factor to be reckoned with. Fick, Soret, and others have made it clear that when a solute is in contact with a solvent it tends to diffuse into the solvent until equally distributed through it. The diffusion gradient consequent upon Fick's law supplies a directive agency and a means of acceleration the moment precipitation begins within the field of diffusion. Its operation is slow but relentless. The force actuating the diffusion of salts has not been measured directly, but its supposed equivalent in osmotic pressure has been equated and measured, and found in certain instances to attain a magnitude of many atmospheres. Thus we already know that where there is water and a solute, the latter will tend to migrate through the former without cessation until equally dispersed through it; and when obstructed it will be assisted by the force of osmosis. Given the time, then, which is required for the flow of large volumes of water through a great thickness of firm rock, diffusion is a factor to be considered. The particular utility of that concept in assisting the understanding of the phenomena of vein genesis lies in the subtlety, mobility, efficiency, and vector quality of diffusion.

Knittel,[1] in 1922, finds small quantities of platinum and palladium in the anode slimes resulting from the electrolytic refining of silver recovered by smelting ores from the Cobalt district.

Watson,[2] in 1922, in a general review of the Cobalt silver area points out that the main Cobalt area is four miles long by two miles wide, and that in this area there were about thirty producing mines. Diligent exploration for years has failed to extend the limits of the main area, although the formation is favourable on three sides.

---

[1] Notes on the Detection and Estimation of Small Amounts of Platinum and Palladium in the Presence of Large Amounts of Silver, by G. A. Knittel, Can. Chem. and Met., Aug., 1922, p. 179.

[2] R. B. Watson, Financial Post, Toronto, Oct. 27, 1922.

The ores are found over a stretch of country from South Lorrain to Gowganda; this shows that the solutions depositing the ores came from different sources, or at least have been widely distributed from the same source. This leads to the hope that other occurrences will be found in the great area of favourable rocks in northern Ontario.

The most remarkable feature of the Cobalt camp from the investor's standpoint is the large per cent. of the money received from the sale of ore, which has been returned to the stockholders in dividends. The Nipissing, for instance, up to the end of 1921, had produced $41,000,000 worth of ore, and had disbursed $23,640,000 in dividends. Adding the cash and ore on hand brings this latter figure up to $27,000,000. In other words, the stockholders have received in dividends 66 per cent. of all the money taken in.

He considers that it takes a long time for a good camp to die. On the older properties the favourable territory has been pretty well prospected; the easy ore has been found. There is a large area, however, which is overlain by the diabase sill; the contact of this sill with the underlying rocks offers possibilities for the adventurous. Prospecting for these contact ore bodies will be expensive on account of the lack of surface indications, and is not likely to be generally undertaken, except where the contact can be reached without great expense, or where the conditions indicate an ore-body at a certain place, such as at the Colonial where a vein on the adjoining property, the O'Brien, has been developed.

Knox,[1] in 1922, discusses an effect of climatic change on the superficial alteration of ore deposits, and cites as examples the Keeley mine in South Lorrain and the group of copper deposits at Soymanovsk near Kyshtim in the Urals.

Burrows and Hopkins,[2] in 1922, map and report on an area which lies to the north and northwest of Lake Timiskaming. They find the succession of rocks the same as that described by Miller in the Cobalt area. In Mulligan township, however, an area of mica schist was met with which they state resembles the Couchiching of Western Ontario. They also encountered a massive altered diabase which in their opinion may be pre-Algoman in age.

In Cane and Auld townships there are a number of veins of calcite and dikes of aplite containing silver. They occur toward the hanging-wall side, or upper part, of the diabase sill.

The gold deposits of Bryce township are described.

Parsons,[3] in 1922, describes the hemimorphic character of a crystal of proustite from Cobalt.

Burrows,[4] in 1922, finds that in Gowganda nearly all the silver occurs in the Nipissing diabase at the top of the sill. In addition to those veins found in the diabase, a few silver-bearing veins have been discovered in the Keewatin greenstone, and the conglomerate of the Cobalt series. Where the discoveries in the Keewatin and diabase have been made, these formations overlie the diabase sill and the veins are near the hanging-wall contact. At the Millerett mine (Miller Lake-O'Brien) 500,000 ounces of silver were produced from conglomerate of the Cobalt series above the Nipissing diabase sill. In Gowganda no silver-bearing veins have as yet been found in rocks that lie below the diabase sill.

---

[1] An Effect of Climatic Change on the Superficial Alteration of Ore Deposits, by Henry H. Knox, Econ. Geol., Vol. XVII, No. 8, Dec., 1922.

[2] Blanche River Area, by A. G. Burrows and P. E. Hopkins, Ont. Dept. Mines, Vol. XXXI, pt. III, 1922.

[3] A Third Type of Proustite from Cobalt, Ont., by A. L. Parsons, University of Toronto Studies, Geological Series No. 14.

[4] Gowganda Silver Area, by A. G. Burrows, 4th ed., Ont. Dept. Mines, Vol. XXX, pt. III, pp. 1-54.

He classifies the rocks as follows:—

Post-Keweenawan . . . . Olivine-diabase, quartz-diabase aplite.
Keweenawan . . . . Quartz-diabase (sill).

Intrusive contact

Animikean (Cobalt Series) . . . . . . { Upper: Conglomerate, quartzite, arkose.
{ Lower: Conglomerate, greywacké, quartzite.

Unconformity

Laurentian(?) . . . . Granite, syenite, gneiss.

Intrusive contact

Keewatin . . . . Basic and acidic volcanic and intrusive rocks, iron formation, chlorite and hornblende schist, etc.

Bastin,[1] in 1922, makes a study of the native-silver ores near Wickenburg, Arizona, and compares them with the silver ores at Cobalt. His conclusions are as follows:—

1. The ores of the Monte Cristo mine, near Wickenburg, Ariz., occur as replacement veins in rocks of probable pre-Cambrian age. There is no direct evidence of the age of the mineralization. If, as seems likely, these veins were formed contemporaneously with most other ore deposits of this region, their age is probably late Tertiary.

2. The minerals listed below were noted in the Monte Cristo ores; the commoner ones are shown in italics.

Primary (hypogene): *Chalcopyrite, pyrite, arsenopyrite*, sphalerite, galena, *tennantite*, enargite, specular hematite, *quartz, barite*, magnetite, *niccolite, chloanthite*, gersdorffite, *native silver*, proustite, pearceite, argentite, *calcite*, and *siderite*.

Secondary (supergene): Argentite (?), erythrite (cobalt bloom), annabergite (nickel bloom), and limonite.

3. Although several ore types are recognizable there is no clear evidence of more than one general period of primary mineralization.

4. The microscopic relations in the Monte Cristo ores show clearly that the silver-bearing minerals—native silver, proustite, and pearceite—are primary (hypogene), having crystallized contemporaneously with several of the commoner and unquestionably primary ore minerals. These three silver minerals never replace other minerals in these ores.

5. In some of the Monte Cristo ores argentite has replaced native silver. This argentite is clearly contemporaneous with calcite and is believed to be late primary (hypogene) rather than secondary (supergene).

6. Downward enrichment in silver is negligible unless some argentite is to be interpreted as secondary (supergene). Downward enrichment in copper is limited to the formation of peacock tarnishes on chalcopyrite.

7. Waters dripping through the vein are neutral.

8. Oxidation has been slight.

9. The undoubted primary association of native silver with nickel arsenides in the Monte Cristo mine lends credence to the view that the native silver associated with cobalt and nickel arsenides and antimonides at Cobalt, Ontario, and elsewhere may also be mainly primary.

10. The native silver at Cobalt differs from that at the Monte Cristo mine in that it is not contemporaneously intergrown with the cobalt and nickel arsenides and antimonides but has replaced them. For this reason it has been thought by some to be a product of downward enrichment through the agency of solutions carrying silver in balance with the sulphate radicle. The field relations at Cobalt indicate, however, that the rich silver ores are primary and offer apparently insuperable obstacles to the hypothesis of downward enrichment.

11. The abundance of carbonates and the absence of sulphates in the Cobalt ores suggest that in the mineralizing solutions silver was carried in balance with the bicarbonate rather than the sulphate radicle.

12. A restudy of typical Cobalt ores showing that silver and calcite have simultaneously replaced niccolite also suggests that silver deposition was accomplished by carbonate rather than sulphate solutions.

13. Qualitative experiments prove conclusively that cobalt and nickel arsenides and antimonides are effective precipitants of metallic silver from silver bicarbonate solutions, nickel and cobalt being simultaneously taken into solution. The reactions are analogous to those previously worked out quantitatively for silver sulphate solutions, except that the solutions remain neutral after the reactions.

14. The field relations of the Cobalt deposits, the microscopic relations of the silver to the other ore minerals, experimental work with silver bicarbonate solutions, and partial analogy with the Monte Cristo ores all appear to favour the hypothesis that the rich native silver ores of the Cobalt district are late primary (hypogene) deposits from bicarbonate solutions.

---

[1] Primary Native Silver Ores near Wickenburg, Arizona, by Edson S. Bastin, Bull. 735E, U.S.G.S., 1922.

Sir Edmund Walker,[1] in 1922, in his presidential address to the shareholders of the Canadian Bank of Commerce remarks that for three-quarters of a century our geologists and other Canadians of reasonable intelligence have known that we possess in the centre of Canada the largest area in the world of the oldest rocks and of rocks immediately following these, all roughly classed as pre-Cambrian. These are most promising areas for the prospector. But we also possess in the Maritime Provinces and eastern Quebec our share of the Appalachian mountains, and in the far west our share of the vast Cordilleran areas. Of gold, silver, nickel, copper, asbestos, and other metals we are already important producers. We have iron ores in plenty, but these are not so readily available as the ores mined in that comparatively small extension of our pre-Cambrian area into the United States, which is so wonderfully rich in iron and copper as to be famous throughout the world. What we have accomplished thus far in the three great mining areas has been largely the result of accident; we can hardly pretend that there has been serious prospecting in many of the mining fields of Canada, except by a very small number of trained experts.

Collins,[2] in 1922, publishes a geological map of northern Ontario. This map includes Cobalt, Porcupine, Kirkland Lake, and Sudbury, and the country as far west as Lake Superior. It also embraces a narrow fringe of western Quebec. The legend published with the map appears below.

LEGEND

(After W. H. Collins)

QUATERNARY		**Glacial drift and post-Glacial lake beds**
PALEOZOIC	SILURIAN AND ORDOVICIAN	**Limestone, shale and sandstone**
	KEWEENAWAN	**Killarney granite and gneiss** **Quartz diabase and quartz norite intrusives** The Thessalon greenstone and later olivine-diabase dykes are included in this group, although not of exactly the same age.
HURONIAN	WHITEWATER SERIES	**Conglomerate and sandstone** **Trout Lake conglomerate, Onaping tuffs, Onwatin slate and Chelmsford sandstone**
	COBALT SERIES	**Lorrain quartzite, banded cherty quartzite and upper white quartzite** **Gowganda formation** (conglomerate, greywacké, quartzite and limestone)
	BRUCE SERIES	**Serpent quartzite** **Bruce conglomerate, Bruce limestone, Espanola greywacké and Espanola limestone** **Mississagi quartzite**
PRE-HURONIAN	BATHOLITHIC INTRUSIVES	**Granite-gneiss and related acid plutonic rocks** **Gneiss** A complex association of igneous granite and granite gneiss with highly metamorphosed sedimentary materials (stratiform gneisses, quartzites and crystalline limestone) of Grenville-like appearance. Hitherto believed contemporaneous with gneiss above, or older, but the igneous members are now known to be in part, if not altogether, of the same age as the Killarney granite.
	SEDIMENTS	**Doré series, Sudbury series, Timiskaming series, Pontiac series** These sedimentary series, though grouped together as pre-Huronian sediments are not known to be of the same age.
	VOLCANIC COMPLEX	**Iron formation** (differentiated in places from the schist complex.) A schist complex essentially of volcanic origin; but containing some obscure sediments of pyroclastic origin and undifferentiated areas of iron formation.

---

[1] Presidential Address to the Shareholders of the Canadian Bank of Commerce, 1922, by Sir Edmund Walker.

[2] Map No. 155A, Portions of the District of Algoma, Sudbury and Timiskaming, Canadian Geol. Survey.

Miller,[1] in 1923, writes as follows:—

> In northeastern Ontario, as is well known, the pre-Cambrian consists of a great variety of both igneous and sedimentary rocks that represent a vast period of time. In this region are also to be found some of the world's greatest gold, silver and nickel deposits. The age and structural relations of the rocks have been closely studied during recent years chiefly owing to their bearing on economic problems, and it has been found that owing to the variety of ore occurrences it is necessary to have a more detailed knowledge of the rocks than is required in most regions if prospecting and mining problems are to be satisfactorily solved. There is need of a knowledge of what rocks are genetically or structurally connected with certain ores and those that are not. For example, an older series of sediments, the Timiskaming, is found to be structurally related, at least, with the occurrence of gold deposits that are now productive, and certain acid rocks are genetically related to the same deposits. On the other hand, a newer series of sediments, the Cobalt series, is younger than the gold deposits, but in it has been found a high percentage of the silver ores. The silver deposits are genetically connected with certain diabases, the Nipissing series, that occupies large areas in the region.
>
> It is difficult to distinguish certain igneous rocks from others that may be either younger or older, unless they are found in contact with rocks whose ages are known. The same may be said of certain sedimentary rocks of the region. But for economic reasons it is necessary to determine if possible the age relations. Prospectors, for instance, have spent time in searching for silver deposits in diabases that they mistook for the Nipissing diabase but which were really of much greater age. Similarly, older porphyries have been mistaken for the newer, that are associated with gold deposits.
>
> A good example of a series of older diabases that have in one or two areas, at least, been mistaken for the newer Nipissing diabase is recorded by Mr. A. G. Burrows in his reports on the Matachewan and Gowganda areas.

Similar observations have been made by Dr. H. C. Cooke on the occurrence of diabase dikes in the Matachewan area. D. G. H. Wright has also found the same series of dikes in the Watabeag area. Miller has named these diabases the Matachewan series.

Miller shows in the following table the relative position of the Matachewan series:—

EOZOIC OR PRE-CAMBRIAN

Upper	(Keweenawan)—Nipissing diabase, etc., of N.E. Ontario. Animikean—sediments of Cobalt series, etc.
	Great Uncomformity
Middle	(Matachewan)—diabase dikes, etc. (Algoman)—granite, porphyry, etc. (Haileyburian)—lamprophyre, diabase, etc. Timiskamian—sediments.
	Great Unconformity
Lower	(Laurentian)—granite, etc. Grenville—limestones, etc. (Keewatin)—basic lavas, etc.

Miller,[2] in 1923, constructs a diagram which shows the triangular relations of Sudbury, Cobalt, and Porcupine.

Knight,[3] in 1923, reports on the South Lorrain silver area. His report forms Chapter III of the present report.

Walker,[4] in 1923, describes a coarsely porphyritic dike of diabase from Gowganda. The diabase is fine-grained and shows typical ophitic structure. The augite is fairly fresh, though the plagioclase is so strongly altered that only on the outer zone of an occasional crystal can the characteristic twinning be observed. The porphyritic crystals are somewhat rounded, are pale yellowish-green, and attain a diameter of one and a half inches. An analysis of the phenocrysts gave the following results:—

---

[1] The Matachewan Series and its pre-Cambrian Relations, by Willet G. Miller, Can. Min. Jour., April 20, 1923.

[2] Ontario's Triumvirate of Great Mining Areas—A Remarkable Triangle, by Willet G. Miller, Can. Min. Jour., June 22, 1923

[3] The South Lorrain Silver Area, by Cyril W. Knight, Ont. Dept. Mines, Bulletin No. 48, 1923.

[4] Huronite from Gowganda, Ont., by T. L. Walker, University of Toronto Studies, Geological Series No. 16, 1923.

	per cent.
SiO_2	46.98
Al_2O_3	30.18
Fe_2O_3	.95
FeO	.42
CaO	9.38
MgO	.39
MnO	.04
Na_2O	1.36
K_2O	6.40
H_2O	4.05
CO_2	.27
	100.42

Walker believes this material to be scapolite, a mineral into which basic plagioclase frequently alters. In thin sections under the microscope the phenocrysts are seen to be composed of an exceedingly fine-grained aggregate, which is somewhat fibrous in texture.

Miller,[1] in 1923, describes the geology and ore deposits of the Cobalt area. This is a reprint of the Guide Book prepared for the International Geological Congress in 1913.

Bastin,[2] in 1923, during the month of August, writes as follows:—

> The veins of the Frontier mine (South Lorrain) follow steeply inclined zones of fracturing of general northerly and southerly trend. The ore has been deposited in part as a filling in open cracks as in the Watson vein, third level, where open cavities lined with successive layers of ore minerals are common. In the main, however, the work has shown that most of the ore has been deposited by the process known as replacement. Where the veins now are there existed prior to mineralization zones where the rocks were traversed by numerous nearly parallel fractures or where they had been crushed to an aggregate of small fragments. Large open spaces were rare. Along these fractured and brecciated zones the mineralizing solutions circulated dissolving rock material and depositing ore minerals in its place. Even some of the veins that are sharp-walled have been formed in this way. The practical importance of recognizing replacement as the dominant method of mineralization lies in the fact that in the deposition of replacement veins variations in (a) kind of wall rock, (b) degree and manner of fracturing, and (c) extent of development of clay or gouge, exert a much larger control on mineralization than they do in the filling of open fissures. A small gouge-lined fracture may suffice to terminate abruptly an ore-body forming by replacement by acting as a barrier to the replacing solutions.

He finds that calcite, usually pink and iron-bearing, is the dominant gangue mineral. Quartz is also present.

The metallic minerals are:—

Arsenopyrite ($FeAsS$) } Usually Dominant Metallics
Cobaltite ($CoAsS$) }
Löllingite ($FeAs_2$)
Niccolite ($NiAs$)
Breithauptite ($NiSb$)
Chalcopyrite ($CuFeS_2$)
Tetrahedrite ($4Cu_2S.\ Sb_2S_3$)
Pyrite (FeS_2)
Galena (PbS)
Argentite (Ag_2S)
Proustite (ruby silver) ($3Ag_2S.\ As_2S_3$)
Sphalerite (ZnS) (Bismuthinite) (Bi_2S_3)
Native silver
Native bismuth

> Although the gray metallics of the veins commonly go under the name of "smaltite" most of what has been termed "smaltite" is an intimate mixture of arsenopyrite and cobaltite with in places some löllingite. Further study may reveal some true smaltite.
>
> All of the minerals listed above are unquestionably primary with the following exceptions:—
>
> 1. A small part of the silver.
> 2. Possibly some proustite.
> 3. Possibly some argentite.

---

[1] The Cobalt Area, by Willet G. Miller, Ont. Dept. Mines, Guide Book, Sudbury, Cobalt, South Lorrain, Kirkland Lake, Porcupine, and Timagami, 1923.

[2] The Frontier Mine, South Lorrain, by Edson S. Bastin, Special Report to the Shareholders of the Mining Corporation of Canada, Ltd., Sept. 17, 1923.

> The study under the microscope of polished specimens of rich ore representative of all parts of the mine shows definitely that nearly all of the native silver of the mine is primary. Some of it is early primary and is contemporaneously intercrystallized with niccolite that was one of the first ore minerals to deposit. Most of the silver is, however, late primary and occurs together with calcite, tetrahedrite, chalcopyrite, sphalerite, and bismuthinite, in veinlet-like masses traversing the commoner metallic minerals and clearly the last portions of the ore to crystallize.
>
> The evidence that most of the native silver is primary is definite and conclusive, and warrants the confidence that shoots of rich ore may be encountered to considerable depths unless other factors such as decrease in the degree of fracturing and of replacement with depth interfere.
>
> In portions of the Wood's ore-shoot above the third level, argentite is abundant lining small vugs in very rich ore. This argentite interlocks intimately with undoubted primary minerals and seems itself to be primary. It was one of the last of the primary minerals to deposit. Further study may show that some argentite is a secondary deposit from descending solutions, but if present at all its quantity is unimportant from the commercial viewpoint.
>
> Teeth and wires of native silver occur implanted in primary argentite in vugs in some of the ore of the rich Wood's stope. This silver is clearly an alteration product of the argentite. Ordinarily this alteration would be attributed to enrichment by waters descending from the surface, but in a few places the wires and teeth of silver have been partly reconverted to argentite —a change not characteristic of the action of descending surface waters. Further study may show that the formation of the silver wires and teeth had no connection with surface processes. At all events the silver values in the form of silver wires and teeth are small as contrasted with the more massive silver which is clearly primary, and the question of their primary or secondary origin is of minor practical importance.

Bell,[1] in 1923, describes the pre-glacial weathering of Wood's vein to a depth of 560 feet at the Keeley mine. He believes that some of the silver is secondary. His views are given more fully elsewhere in this report.

The Imperial Mineral Resources Bureau,[2] in 1923, gives an excellent review of the geology, production, and so forth of the Cobalt silver field. The report also deals with the silver fields of the British Empire and foreign countries for the period 1913 to 1919.

Spurr,[3] in 1923, expresses the opinion that the veins at Cobalt are clearly intrusive veindikes, with perhaps some replacement of the wall rock on both sides of the veindike fissures. He considers that the veins have all the characteristics of true veindike fissures. They are branching and reuniting injections, enclosing isolated, sharp, angular fragments, and also long slabs of country rock. Successive substages or episodes of vein injection are shown, as in one specimen which shows an earlier injection of a smaltite (with much fine disseminated niccolite) veindike which was split along one wall, and a later injection of niccolite and calcite forced up. The occurrence of niccolite in both injections shows that these injections followed one another closely in point of time and constitute a phenomenon of fractional splitting, or magmation of the ore magma, which elsewhere in Cobalt frequently crystallized as a single veindike combining both these episodes; and that, therefore, these examples are hardly to be regarded as true compound veins, any more than are the veins at Porcupine or at Kirkland lake. The Cobalt veins are in the large sense one-stage veins exhibiting the usual differential crystallization, whereby some elements overlap and partially succeed others, where the crystallization was slow enough to allow this differentiation or magmation. Another instance of sequence of vein crystallization, which he observed in a specimen at the exhibit of Cobalt ores at the Nipissing mill, showed on the walls of a little veindike a first deposition of quartz, with a centre of arsenides (smaltite, etc.) and native silver. There was no second splitting here; the phenomenon was that of sequence of crystallization from an ore magma filling and distending a fissure which it had intruded—and cooling with sufficient slowness to permit in this unusual case a gradual crystallization.

---

[1] Deep-Seated Oxidation and Secondary Enrichment at the Keeley Silver Mine, by J. Mackintosh Bell, Econ. Geol., Vol. 18, No. 7, Oct.-Nov., 1923.

[2] The Mineral Industry of the British Empire and Foreign Countries. War period. Silver. Imperial Mineral Resources Bureau, 1923. Printed and published by His Majesty's Stationery Office, London, England.

[3] The Nature of the Silver Veins at Cobalt, by J. E. Spurr, Eng. and Min. Jour.-Press, Oct. 27, 1923, pp. 709-712. The above is quoted practically word for word from Mr. Spurr's article.

The tendency of metals, in congealing ore magmas, to crystallize later than the bulk of the gangue minerals and also to segregate towards the walls (under gaseous tension pressure), or even to escape from the veindike into the walls or upwards into a just-crystallized portion of the veindike, to which tendency he has called attention as a rule of ore magma crystallization and has recently pointed out at Porcupine, is well illustrated at Cobalt, on a striking and important scale, by the occurrence of native silver, which characteristically partially escaped the veindikes, and occurs in crevices in a zone of country rock on either side, forming sheets and films of silver, and which, moreover, fills cracks and crevices in the earlier crystallized calcite-arsenide—native silver veindike, just as at Porcupine native gold does in the earlier crystallized quartz (gold) veindike. This silver-impregnated country rock, extending often several feet away from the veindikes (which themselves carry far more silver and constitute the phenomenonally rich ore) makes up the considerable tonnage of low-grade or milling ore of the district. In the veindikes themselves, this late crystallization and high degree of mobility of the native silver has procured an irregular concentration of silver; so that, while some of the veins seen were reported to carry locally several thousand ounces of silver to the ton, similar veins and indeed other portions of the same vein, carry very little silver, while representing the same veindike intrusion, as shown by the presence of all the rest of the minerals of the characteristic veindike fabric, such as calcite, smaltite, and niccolite. The explanation for the high migrativeness and concentration of native silver above given, involves, of course, an upward as well as outward pressure in the veindikes: accordingly, the tops of veindikes (for some of the veindikes have been found to terminate upwards in the mines, constituting so-called "blind veins") are said to be ordinarily relatively high in silver.

There is no question in his mind that the silver is a primary ore-magma mineral: not the result of alteration and concentration by surface waters, whose effect at Cobalt has been negligible. In Cobalt, indeed, there is practically no zone of oxidation and rearrangement by surface waters, the pre-glacial zone having been gouged away by the glacier, and subsequent (post-glacial) time proving to have been inadequate for much superficial decomposition. Knowledge of this type of ore deposit is recent, and when the rich native-silver ores were discovered and were later found to fail characteristically at a certain depth, geologists with knowledge of the formation of native-silver ores in the western United States, by reduction from sulphide ores under the influence of descending waters, were naturally inclined by analogy to regard the Cobalt ores as also secondary. But events and a better conception of the geology have proven that the analogy was a false one, and that the native-silver ore here is primary and truly magmatic.

The great influence of wall-rocks in determining the locus of precipitation of the net final fraction of the ore magma is as striking at Cobalt as at Porcupine, or even more so. At Porcupine, it will be recalled, a gold quartz veindike (for example in the McIntyre mine) which runs from the (basic) Keewatin schists into the siliceous porphyry, is apt to lose most of its gold values, though the veindike itself may proceed bravely on. And at Cobalt 80 per cent. of the ore has come from the conglomerates and other sediments of the Cobalt series, into which series the diabase has intruded. Most of these exposed sediments at Cobalt underlie the diabase sill which has been partly stripped off by erosion; and veins pass downwards from the conglomerates into underlying Keewatin (basic) schists, representing ancient lava flows, essentially like those of corresponding age of Porcupine. Many of the veins lose much or practically all of their silver values when traced (downward) from the conglomerates into the Keewatin, while the vein itself (of smaltite, niccolite, calcite, etc.) sometimes proceeds on in full width. The controlling influence of the wall-rock on the precipitation of the final (silver) fraction of the ore magma is clear; and the explanation of this striking phenomenon is as nice a problem as it is in Porcupine —or even more exacting.

Considering first the chemical influence of wall-rocks on silver deposition, he has pointed out that the basic derived ore magmas, being calcic, would be most influenced to precipitation by siliceous wall-rocks, just as the siliceous-magma-derived ore magmas, being themselves siliceous, are best influenced to precipitation by basic wall-rocks. This would appear to be upheld at Cobalt, where the conglomerate and other sediments of the Cobalt series, containing a large amount of granitic material, should precipitate from calcic solutions more readily than should either Keewatin schists or the Keweenawan diabase, both basic rocks.

Bell,[1] in 1923, discusses the geology and ore deposits of South Lorrain. He says:—

> The Nipissing diabase, in South Lorrain, occurs in the form of a wide sill that, after being folded into a broad dome, was subjected to pronounced faulting and long-continued erosion. To day, the centre of the formerly continuous dome is mainly a valley underlain by rocks of the Cobalt series and occupied by numerous small lakes, the largest of which are Loon and Oxbow. Along the outer slopes of the dome, Keewatin rocks are conspicuous; these, in turn, are generally overlain by rocks of the Cobalt series. Silver ores in appreciable quantity have been found in two localities only, namely along the western slope, where are situated the Keeley and the properties of the Mining Corporation, and along the northeastern slope, where the Canadian Lorrain silver mine is situated. The latter area is unimportant and, for the purpose of this paper, only the area adjacent to the Keeley and the properties of the Mining Corporation need be considered.

He considers that certain generalities govern the position of the ore-shoots in South Lorrain and Cobalt:—

> (1) Generally speaking, the richest and most persistent ore-shoots occur at or near the diabase—Keewatin contact, either within the diabase or within the Keewatin; the immediate contact is commonly barren or of low grade.
>
> (2) The junction of one vein with another, even a considerable distance from the contact, affects the values, either in one vein or the other, or in both. If the veins are valueless before joining, an ore-shoot of greater or less length is commonly made in the united vein.
>
> (3) The values within a sufficient distance of the contact, even in the smaller veins, are likely to improve when the deposit occurs in a well-fractured zone, with cracking developed parallel to its strike.
>
> (4) Ore-shoots are frequently localized on a main vein between the points of departure of two minor branching veins, or between the points of crossing of two zones of fracturing.
>
> (5) When the ore-shoots are in Keewatin rocks, the most favourable rock is an extremely dense, fissile, well-fractured greenstone. Lamprophyre is generally less favourable, though some of the richest ore is found in fault planes where greenstone occupies one wall and lamprophyre the other.
>
> (6) Generally speaking, the veins are more likely to carry ore where the dip of the vein is steep (upwards of 70°) than where it is flat. Wood's vein, however, carries large amounts of ore when the dip is as low as 60° or even less.
>
> (7) It is noteworthy that where the dip of a vein varies from the vertical in both directions, one inclination may be productive and the other not.
>
> The origin of the veins of South Lorrain, with their rich ore-shoots, is similar to that of Cobalt, where the question has received much attention from various authorities. The writer has given his opinions in this connection elsewhere and considers it unnecessary here to do more than

---

[1] South Lorrain Silver District, Ont., by J. Mackintosh Bell, Trans. Am. Inst. Min. and Met. Eng., Jan. 1924.

repeat his conviction that while the greater part of the ore is primary and due to hypogene agencies, there has been, in places, material enrichment by descending solutions that derived their silver content from the now improverished portions of the oxidized zones.

Bastin,[1] in 1923, considers the native silver at the Frontier mine, South Lorrain, to be primary.

APPENDIX[2]

In the following pages will be found an interesting account of the discovery and history of the Wright silver mine on the east shore of Lake Timiskaming. The Wright mine is one of the oldest in North America. This account of its discovery was published in *The Daily Nugget* in 1921, and in the Canadian Mining Journal. It was written by Mr. J. A. McRae.

In the National Library of Paris are some notes which deal with the discovery of lead ore in 1686 upon the eastern shore of what is now known as Lake Timiskaming. These notes were taken from the diary of Sieur de Troyes, and are referred to as "Relations and Journal of a journey to the North by a detachment of one hundred men under the command of 'Le sieur de Troyes,' in date of March, 1686."

Thus it was that at a time when a few venturesome souls, some of them perhaps with nothing short of an empire in their brains and some of them merely the coureurs des bois of a new continent, were engaged in the difficult task of establishing the white race in North America, an ore deposit was discovered, only to be lost, then found again after the sway of the Indian tribes had become dissipated before the advance of civilization in Canada.

Names of Officers of the Detachment in 1686

Chaplain—Rev. Father Silvie, Jesuite.
Commander—Sieur de Troyes.
Lieutenant—Sieur de St. Helene.
2nd Lieutenant—Sieur de Hyberville.
Major—Sieur de Maricourt.
Assistant Major—Sieur de La Noue.
Board Commissioner—Sieur Lallement.
(Also designed to command a vessel in case we should not locate one to come to Quebecq).
Captain of the Guides—Sieur de St. Germain.

Narrowly Missed Altering Tide of Progress in North America

It is perhaps one of the strangest chapters in Canadian history that while attention has turned to the mineral possibilities of the country as far back as 1686, following this discovery on the eastern shore of Lake Timiskaming, yet within three miles of the western shore of the same body of water the fabulously rich silver veins of the Cobalt district actually lay bleaching in the sun until accidentally found in 1903.

Just here, it is interesting to indulge in conjecture as to what influence the discovery of these vast riches in native silver might have had upon early settlement on the North American continent. It seems quite safe to assume that had Cobalt been found in 1686, the attention of the Old World would have been focused with great intensity upon this region. It is not unreasonable to suppose that the tide of immigration to North America would have been in this particular direction. It is probable that bitter jealousies would have grown in the breasts of those who were blazing the western trails for France and those who were steering the destiny of Anglo-Saxon influence in the New World.

It is one of the marvels of the opening of Northern Canada that for more than two centuries white men, armed with all the inquisitive instinct of the race, should have trekked along Lake Timiskaming, camped upon its shores, and failed to receive any intimation from their fellows or from the natives of the rich silver veins lying in the very shadow of their camps.

But, to turn again to the history and romance of the Wright Mine: The following are notes as taken from the Commander's diary, dating from May 12 to May 24, 1686, the date on which the lead deposit was found.

The Diary of Sieur de Troyes

On May 12th—We reached 'Mattawan', which signifies in Indian language "Fork of Rivers": one being at a point that the left is to the south, and the road of Ottawa's to the right, which is north. Consequently my road leads me to Temiskamingue. I arrived at this place of Mattawan very early; this gave an opportunity to the Rev. Father Sylvie to celebrate Holy Mass. We were at a point where the Indians were camped, and were making canoes. They seemed to be greatly surprised to see such a lot of people. It had snowed in the morning, but the evening was very nice: I had dined with Sieur Juchereau that came from Michilmakina, and was going to Quebecq in a great hurry to bring news to Monsieur le Marquis de Denonville. He had arrived as I was having dinner, and continued his journey shortly afterwards, to gain time on his route. In the same time I ordered Sieur de St. Helene with three of our canoes to go and meet Mr. d'Hyberville.

---

[1] Primary Native Silver Ores of South Lorrain near Cobalt, Ont., by Edson S. Bastin, Geol. Soc. Am., 36th Ann. Meeting, Washington, D.C., 1923.

[2] *The Daily Nugget*, Cobalt, 1921, and Can. Min. Jour., Aug. 19, 1921.

On May 13th—It rained, snowed, and strong wind all day; also continued the next day till noon. Monsieur d'Hyberville arrived and told me he had uselessly waited for two days for the canoe I had made him wait for.

I was very suspicious of the Indians; consequently in order to keep my staff on the watch, I had ordered that nobody on the guard should sleep, and on the first alarm, they were to put out a small fire, and in one word everybody was ready and in order, the arm in hand.

I got a cross erected on the point of the Fork, and our English interpreter opened his leg to the bone with a stroke of the axe. We count from the Island of Montreal to Mattawan one hundred leagues (or 250 miles).

On May 15th—We could not start before sunrise on account of portaging we had to do in water which was extremely cold. We left after Mass was celebrated, and having made three portages, we camped one league higher than the first, and three and one half from Mattawan. One of our canoes was broken in pieces in the second portage. Having landed in a rapid, we saved the contents, but we got some of the staff hurt. I got in the canoe of the Captain of our Guides, an Indian that knew the road of the "Bay" perfectly well. I hired him in Mattawan.

On May 16th—We were camped eight leagues from Mattawan, one league above the fourth portage. The road is very bad and for three hundred feet long, Sieur de Ste. Helene was dragging.

On the 17th—We went up again and the place that we name "The Long of the Soo." It is two leagues long and is extremely difficult on account of its great current. We had to pole it nearly all the way, and dragged it in five or six different places. We got some canoes damaged and we camped above the last rapid.

On the 18th—We left in the morning, and left although there was a big storm that lasted very well near all day. Arrived at the house of Messrs. The Company of the North. This company is on an island of Lake Temiskamingue: it may have one half a league of circumference and between two rapids proceeding from a little river called "Matabec Chouan" in Indian, from which some Indians come out to trade. There were fourteen Frenchmen in this house for the Company that were as joyful as we were of our arrival, that we celebrated from parts and others by several shots of guns.

On the 19th—And two following days, the weather was very unfavourable, Messieurs de Ste. Helene and d'Hyberville employed with Monsieur de St. Germain business of the Old and New Company, and furs that were in the store, where they appointed Sieur Sibille to render accounts of all to the company. We left him four men to make the trade with very little provisions. Sieurs Guillet and Villedieu stayed for three days at Nipissingue, Savage Nation, to get canoes made and to bring them to Montreal. As for us, we traded with the Indians that were close to our house to replace the ones we had, and that we had left there on account of them being too large and too heavy for the balance of our journey. I was very careful to put two good canoe-men for every canoe in order to jump the rapids.

On the 22nd—It rained a part of the day; this did not stop us from going after celebration of Mass, followed by three canoes to go and visit a mine at six leagues from the house. I gave orders to Sieur de Ste. Helene that I left, to settle the affairs and to join me the next day with the balance of the staff, and to keep in the Lake the route of the North, to facilitate his joining me. Two leagues from the house, I met three Indian camps that traded a small canoe of four places with me, that I made use of the balance of my journey and for my route to Quebecq. I camped from there on an island: weather not permitting me to go farther.

On May 23rd—After Mass we walked to search the mine. The man Coignac guided us. We met in our search an Indian camp in which the people the previous day had killed a big moose. This gave me an opportunity to camp close to them, and in order that Coignac would find the mine easier. He looked for it uselessly the balance of the day: during this time the two lieutenants left the house to join me with all our staff, but a big storm separated them; ones took the south and others took the north. One part got on islands, this was the cause of very few joining me.

On May 24th—A very heavy wind all day accompanied by rain: but Coignac that had renewed his memory assured me that he recognized himself and that the mine was very close. I got in canoe with him: I paddled in bow and he steered and did not quit our search, although the weather was very bad, to go to the place where Coignac thought the mine was. We found it; indeed this mine is situated to the east and west on the borders of the lake, west of a rock in form of half circle that has fifty feet on the edge of the water, ten feet high from the level of the water, and one hundred feet deep, having no earth on it and losing itself under a mountain covered with rock. We extracted a few small pieces with great difficulty and returned to the camp.

TIME OF THE RE-DISCOVERY

There are no illustrations or drawings in existence which deal with the mine as it appeared more than two centuries ago. Indeed there is but meagre mention made of the deposit until about 1850. It was about this date that Mr. E. V. Wright of Ottawa, who owned the timber in this locality, rediscovered the deposit.

Wright was engaged in removing timber from his concession when the calks on his boots chipped off some of the galena and lead-bearing ore. Samples of the ore were taken to Ottawa where they lay for several years on the desk of the discoverer. About 1870, it occurred to Wright to have the samples assayed. The result of the assay was such as to arouse considerable interest. Shortly after this, Mr. Wright, accompanied by J. M. Courier and Mr. Eustis from Boston, came up and commenced work sinking a shaft to a depth of about 12 feet. From this shaft they took out about ten tons of ore. Details of the result are lacking. It is recorded, however, that a second shipment was made by raft, but the crude conveyance smashed up in a mad plunge through the rapids at Deux Rivières.

Nothing was done until 1885, when George Goodwin, of Ottawa, together with G. T. Brophy advanced sufficient money to pay for sinking the shaft a further 50 feet in depth as well as installing some mechanical equipment and a five-ton stamp mill. This plant was afterwards burned. No ore was shipped as a result of this work.

About 1890, Robert Chapin, at that time president of the Ingersoll Rock Drill Company (N.Y.), bought the property and made an option payment on the basis of $125,000. He installed the first air compressor in the country, and built a fifty or sixty ton mill. He continued the shaft to a depth of 250 feet and did considerable lateral work. This resulted in the shipment of a considerable quantity of concentrates, the value of which seems to be impossible to ascertain at this date. It is said that Mr. Chapin became involved in some bad investments which caused him to abandon this mining project with the result that the property reverted to Wright, the principal holder.

In 1895, Wright sold the property to the Petroleum Oil Trust of London, England. The new owners sunk the shaft another 5 feet in depth and did several hundred feet of drifting and cross-cutting at the bottom level, as well as some work at the 250-foot level. The mill was also operated, the concentrates being shipped to Swansea, Wales. No figures are available as to the amount of concentrates produced.

The mill and buildings as erected by the Petroleum Oil Trust are still standing, although the machirery has been pretty well all removed. The writer visited the mine, June 18, 1921, together with the members of the Ontario Mining Association who were being entertained by the Timiskaming Mine Managers' Association. These buildings are of the old-fashioned type, features being the many gables as well as having a ground floor entrance and a second storey entrance by stairways leading from the ground.

A few years ago, the Wright Mine was bought by the Timmins-McMartin interests of Montreal, and is still owned by them. The underground workings are filled with water, the plant is completely dismantled, and the visitor finds difficulty in throwing off a feeling of peculiar sadness as he views this neglected strange link between Canada of the present day and the wild land of 235 years ago, long before Wolfe took Quebec, and even dating back nearly a year before La Salle, the greatest perhaps of the French pioneers to North America. It was in 1682 that history tells us that in the name of France, La Salle took possession of all Louisiana, from the mouth of the Ohio to the Gulf of Mexico in a resounding proclamation handed down to us. On the column was inscribed "Louis le Grand, Roy de France et de Navarre, regne; le neuvième Avril, 1682." It was four years later that the Wright mine was found, thus linking itself with a past about which only a little is known and which occupies but a dim place in the minds of men.

INDEX

Note.—All references are to the Cobalt silver area unless otherwise stated.

A PAGE

- Acid-wash treatment ... 244, 317
- Adanac silver mine
  - Diabase ... 184
  - Plans of levels ... *In map case*
  - Silver from upper contact ... 7
    - production ... 27
- Adanac Silver Mines, Ltd ... 177
- Aero-brand cyanide ... 296, 297
- Agaunico silver mine.
  - Diabase sill, section ... 174
  - Gold; cobalt; development ... 185
  - Lower contact ... 7
- Agitation (cyaniding) ... 290, 291
- Aladdin Cobalt mine, production ... 25, 161
  - Plans of levels ... *In map case*
- Aladdin Cobalt Co.
  - Capital: dividends ... 20, 161
  - *See also* Chambers-Ferland.
    Kirkland Lake Proprietary.
- Algoman period.
  - Mineral deposits ... 338
  - Ontario, northern ... 30, 31
    - Matachewan area ... 351
    - S. Lorrain tp ... 196
  - Views of Miller and Knight ... 339
- Alice Lorrain mine ... 199, 234
- Aluminium.
  - Precipitation ... 241, 242, 249
    - advantages and cost ... 291
  - Price ... 281, 293
- Amalgamation and cyanidation process. 250
  - *See also* Cyanidation.
- Aman, E. G. ... 204
- Amydaloidal basalt ... 30
- Amydules ... 40
- Analyses.
  - Celestite ... 215
  - Ferric and ferrous ores ... 209
  - Flotation products ... 302, 303
  - Lamprophyre, altered ... 216
  - Phenocrysts, diabase ... 352
  - Quartz-gabbro ... 109
  - Silver precipitates ... 293, 295
    - residues ... 306, 316, 317
  - Solutions using cyanide and sodium sulphide ... 297
- Anderson, H. G. S. ... 318
- Andesite ... 30
- Angus, D. ... 159
- Animikean period.
  - *See also* Cobalt series.
  - Iron formation in ... 338
  - Ontario, northern ... 30
    - Matachewan area ... 351
    - S. Lorrain tp ... 196
  - Views of Miller and Knight ... 339
- Animikie formation ... 325, 326
- Annabergite.
  - Cobalt s. area ... 35, 246

Annabergite PAGE

  - Cobalt s. area—*Continued.*
    - first discovery ... 323
    - order of deposition ... 327
  - Gowganda s. area ... 336
  - Monte Cristo m., Ariz. ... 349
- Antimonides ... 35
- Antimony.
  - Cobalt s. area ... 241
    - first discovery ... 324
    - in native silver ... 37
- Apatite ... 35
- Aplite.
  - Auld and Cane tps ... 348
  - Cobalt s. area ... 337
  - Gowganda area ... 336
  - James tp ... 331, 332
- Aragonite ... 35, 246
- Archean. *See* Pre-Cambrian.
- Area reported on ... 3
- Argentite.
  - Arizona ... 349
  - Cobalt s. area ... 35, 37, 241
    - deposition ... 327, 339, 340
    - flotation treatment ... 251
    - Keewatin ... 246
    - Nipissing s. m. ... 39, 50
  - Gowganda s. area ... 336
  - Silver Islet ... 325
  - S. Lorrain tp ... 214, 352
- Argentum s. m., production ... 27
- Argyropyrite ... 35
- Arizona.
  - Silver ores compared with Cobalt. 349, 350
- Arkose ... 30
- Arsenic ... 241
  - Drummond m ... 158
  - Order of deposition ... 338, 339
  - Percentage in ores ... 330
- Arsenides and Arsenates ... 35, 37
  - Order of deposition ... 340
- Arsenolite ... 35, 323
- Arsenopyrite ... 35
  - *See also* Mispickel.
  - Associated with gold ... 246
  - Deposition ... 339
  - Frontier s. m. ... 352
- Asbolite ... 35, 324
- Associated Gold Mines of West Australia ... 204-206
- Auld tp ... 348

B

- Bailey s. mine.
  - Plans of levels ... *In map case*
  - Production; photo; workings. .26, 157, 172
- Barite.
  - Cobalt s. area ... 35
  - Gowganda s. area ... 336
- Barlow, Alfred E. ... 321-332
- Bartlett, James ... xii, 123, 124, 332

PAGE

- Bartlett s. m. 28
- Basalt 30, 31, 40
  - *See also* Geol. of mine workings.
  - Productive veins in 58
  - S. Lorrain tp. 196, 201
- Bastin, Edson S. 335, 356
  - Notes on:—
    - Frontier m., veins 352
    - Monte Cristo s. m., Ariz. 349, 350
    - origin of Cobalt ores 38, 341
- Bateman, G. C. 93
- Batteries. *See* Stamp mills.
- B. C. 105 loc., rocks 197
- Beaver s. mine.
  - Barren veins 115
  - Diabase 32, 34, 184
    - greywacké in 167
  - Flow-sheets *facing* 274, 276
  - Mine workings 146-152
  - Ore shoot, depth 5
  - Photo 145
  - Plans of levels *In map case*
  - Silver from contacts 7,10
    - production 19, 24
  - Smaltite, depth 343
  - Vein system 130
    - faults in 10, 14
  - Vertical section, coloured *facing* 10, 32
- Beaver Consolidated Mines Ltd.
  - Capital; dividends 20, 148
- Beaver Lake silver mine.
  - *See also* Keeley s. m.
  - Early history 206, 207
  - Workings 217
- Bell, J. Mackintosh 346, 353
  - Acting for Associated Gold Mines of W.A. 204
  - Description by, of workings, Maidens claim 232
  - Notes by, on:—
    - ore deposits of S. Lorrain 355
    - origin of the ores 38
    - Wood's vein 344, 345
  - Secondary character of silver pointed out by 210
  - Work at Keeley m. 195
- Bell, Robert 327-330
- Bellellen s. mine.
  - Description; production 229, 230
  - Plan showing location 203
- Bellellen Silver Mines, Ltd. 230
- Bibliography of Milling Practice 318-320
  - *See also* Literature.
- Big Chamber s. vein 11, 88
  - *See also* Carson vein.
- Big Pete s. vein 157
- Big Pete Canadian Mines, Ltd. 156
- Biotite granite 336
- Birthday vein, Keeley s. m. 210
- Bismuth.
  - Cobalt s. area 35, 246
    - deposition 327
  - Gowganda s. area 336
  - S. Lorrain tp. 352
- Bismuthinite 3, 352
- Black, W. J. 331
- Black River formation 339
- Blake crusher 253
- Blast furnace 305
- Bloom, cobalt. *See* Cobalt bloom.
- Bloom, nickel. *See* Annabergite.

PAGE

- Blue Diamond Coal Co. 128
- Bolivia. *See* Potosi.
- Bonsall s. mine 28
- Bonuses 20, 21
- Bornite 35, 246
- Boulder clay 331, 332
- Boulders, granite.
  - Indicating glaciation (?) 327
- Bowen, N. L. 333
- Boyd Gordon s. mine 28
- Braidwood, A. 5
- Breccia (fault breccia).
  - Definition 12
  - *See also* Cobalt series.
- Breccia conglomerate 323, 325
- Breithauptite 35
  - Deposition 339
  - Frontier s. mine 352
  - With native silver 246
- Bridges, Ralph 319
- Brigstocke, R. W. 158
- Brock, R. W. 329
- Brophy, G. T. 358
- Bruce series 350
- Bryce, Robt. A. 170
- Buchanan, T. R. xii
- Bucke tp. 331
  - *See also* Genesee s. m.
    - North Cobalt s. m.
- Buffalo s. mine.
  - *See also* La Rose s. m.
  - Chloridizing roast 250
  - Cobalt series 64
  - Cost of mining 63, 64
  - Cyanidation 242, 250, 277
  - Faults 13, 143
  - Flotation process 243, 297, 298
  - Flow-sheets 274; *facing* 274, 276; 312
  - Geology and development 66-70
  - Iron formation 166
  - Mercury losses 311
  - Mill for low grade ores 263
  - Ore reserves 64
  - Owners 63
  - Plan of levels *In map case*
  - Silver production 19, 24, 63
  - Veins, location 11
  - Zinc precipitation 291
- Buffalo Mines, Ltd.
  - Capital; dividends 20, 66
- Burk-Remey s. mine 28
- Burnside Gold Mines Ltd. 161
- Burrows, A. G. 4, 8, 10, 343, 348
  - Maidens claim described by 223
  - Matachewan series described by 322
  - Notes on Beaver L. claim 207
    - Forneri claim 235
    - Wettlaufer m 226, 227
  - Views on Gowganda s. a. 348
- Butters, Charles 306

C

- Calcite 35, 37
  - *See also* Geology of mine workings.
  - Deposition and origin 327, 328, 339, 340
  - Keeley s. m., analysis 215
  - Nipissing s. m. 39
  - Veins, carrying Cobalt bloom 119
    - varying values 247
- Calcite Lake s. mine 28

PAGE
Callow, J. M. 297, 320
  See also Flotation process.
Calumet isld., Que. 325
Calumet s. mine 177
Cambro-Silurian. *See* Ordovician.
Camburn Silver Mines, Ltd. 178
Campbell, C. L. 165, 166
Campbell, W. C. 318, 327
Canada, mineral possibilities 350
Canadian Gowganda s. mine 28
Cane tp. 348
Canvas-covered deck 275
Capital of principal mg. companies....20, 21
Carbonaceous material. *See* Graphite.
Carson, Sir John, photo 103
Carson vein.
  See also Big Chamber vein.
  Crown Reserve m.: wealth............ 105
  Keewatin, productive in 104
  Location 11
  Photo 103
  Silver Leaf s. m. 167
Cart lake.
  See also Mercier s. m.
    Seneca-Superior s. m.
  Conditions of erosion and deposition beneath 172
  Keewatin rocks 173
  Leased to Mg. Corp. of Can..63, 171, 177
  Map 168
  Structure 11, 60
  Workings underneath, plan of. *In map case*
Cart Lake s. mine, production 26
Cartwright, B. E. 134, 135
Cartwright, R. A. 134
Casey s. mine.
  Flow-sheet .... *facing* 274
  High-grade ore 13
Casey tp., silver production 18
Casey-Cobalt Silver Mg. Co 18, 20
Casey-Kismet Mg. Co. 18
Castle s. mine, Gowganda 10
Castle-Trethewey s. mine 28
Cataract formation 339
Caustic soda, price 293
Central Operating Co. 165
Chalcocite. 35, 36, 246
Chalcopyrite 35, 246
  Frontier s. m. 352
  Gowganda s. area 336
  Stratification order in milling 275
Chambers-Ferland s. mine.
  Drifts in Right of Way m. used by. 159, 160
  Fault 7
  Mine workings 161-165
  Plan of levels ....*In map case*
  Royalties paid by 22, 25
  Silver production 161
  Veins 49, 54, 55, 127
    Meyer 47, 55
Chapin, Robert 358
Chelmsford sandstone 350
Chert 31, 35, 40
  See also Geol. of mine workings.
Chief isld. 338
Chloanthite 35
  Bellellen s. m 229
  Passing into smaltite 324
Chloridizing roast 250
Chloritic schist. 336
Chromite 338

City of Cobalt s. mine. PAGE
  Cobalt series 64
  Epsomite 36
  Faults 17, 67, 143
  Keewatin, depression in 76
  Mine workings 70-74
  Ore reserves 64
  Owners 63
  Plan of levels ....*In map case*
  Silver from contact 10
    production 23, 63, 70
  Veins, location 11
Cobalt, Ont.
  Cobalt series near 32
  Fault 10
  Map showing location of x
  Photos 2, 240
  Section, vertical, through N. part of....................*facing* 8
Cobalt and cobalt ore.
  Agaunico s. m. 185
  Deposition 338
  Discovery 323
  Fisher-Eplett m. 101
  Frontier m. 221, 224
  Gowganda s. area, amount paid for... 28
  Michipicoten isld. 325
  Mineralogical notes 324
  Nipissing s. m. 59
  Percentage in ores 330
  Price; sources of 325
  Ruby s. m. 2
Cobalt bloom 35
  Arizona 349
  Chambers-Ferland s. m. 165
  City of Cobalt s. m. 65
  Cobalt Lake s. m. 76
  Deposition 327
  Discovery 323
  Gowganda s. area 336
  Hudson Bay s. m. 144
  Keeley s. m. 217, 218
  McKinley-Darragh-Savage s. m...117, 118
  Maidens claim 230
  Port Arthur dist. 325
  Princess s. m. 98
  Right of Way s. m. 160
  Temiskaming s. m. 135-138
Cobalt lake.
  See also Cobalt Lake fault.
    Nipissing s. m.
  Cobalt series, thickness 31, 64
  Emptied 74
  Faults, diagram 14
  Lava flows near, attitude 32
  Structure beneath 11, 32
Cobalt minerals.
  Origin 37
  Stratification order in milling 275
Cobalt series.
  See also Geol. of mine workings.
  Age; composition 30, 326, 337, 339
  Argentiferous 3-10, 31
    production (to 1911) 335
      percentage 354, 355
  Crown Reserve s. m. 105
  Dip of beds 81
  Folding 32
  Millerett s. m. 348
  Ontario, northern 350
    Gowganda s. a. 336
  Sketch, ideal 11

Cobalt series—*Continued.* PAGE
- S. Lorrain tp. 196, 201
- Unconformity 342
- Veins in, more than in other rocks 8
  - productive, number 333, 335

Cobalt silver area.
- Area included in 3
  - productive 347
- Discovery xi, 263
  - account by T. Gibson 331
- Geological formation 30, 326, 350
  - literature 341-358
  - map *facing* 30
- Maps, Index and Geological x, *facing* 30
- Milling and metallurgical practice 241-320
- Mines of, geology and workings 42-188
- Mining claims, map showing *In map case*
- Ore shoots, notes by J. M. Bell 355
- Origin of ores, various views 339-347
- Report (1903) by Miller 322-325
- Re-survey of, correspondence *re* 41
- Silver production 1, 18-27, 263
  - veins, plans showing *In map case*

Cobalt Central s. mine.
- *See also* Penn Canadian s. m.
  - Standard s. m.
- Flow-sheet 274

Cobalt Central Mines Co.
- Capital; dividends 20
- Penn Canadian m. worked by 156

Cobalt Comet s. mine.
- Silver production 24
- Sulphur 310

Cobalt Comet Mines Ltd.
- Capital; dividends 20, 158
- *See also* Drummond s. m.

Cobalt Hill s. vein 330

Cobalt Lake fault.
- Age 17
- Faulting Nipissing diabase sill 32
- General notes 12, 13, 66
- La Rose m. 94, 335
- McKinley-Darragh-Savage m. 16, 93, 115-19
  - photo showing xiv
- Mining on, notes by Nipissing Mg. Co. 59
- Veins in, width and grade; stope sections 75

Cobalt Lake s. mine.
- Flow-sheet *facing* 274
- Ore reserves 64
- Owners 63
- Plans of levels *In map case*
- Profit tax 22
- Silver production 19, 23, 63, 74
- Veins, location of 11
- Workings 75-77

Cobalt Leasors s. mine 17

Cobalt Provincial Mg. Co. 172
- *See also* Provincial s. m.

Cobalt Reduction Co.
- Cost of crushing 260
- Cyaniding 243
- Filter presses 291
- Flow-sheets *facing* 274, 276, 278; 286, 288, 314
- Hypochlorite treatment 315, 316
- Hypochlorite-cyanidation process 250
- Mill, photo and practice 287

Cobalt Silver Queen s. mine.
- Production; development 25, 161

Cobalt Silver Queen, Ltd.
- Capital; dividends 20, 161

Cobalt Townsite s. mine. PAGE
- Cobalt series 64
- Faults 13, 143
- Iron formation 35
- Keewatin, depression in 76
- Ore reserves; owners 63, 64
- Plan of levels *In map case*
- Section, vertical, coloured *facing* 12
- Silver production 19, 23, 63, 78
- Veins, location 11
- Workings, geology and vertical section 78-81

Cobaltite 35
- Associated with gold 246
- Deposition 339, 340
- Forneri s. m. 234
- Frontier s. m. 352
- Origin 328

Clay, boulder 331, 332

Clay, post-glacial.
- New Liskeard, diagrammatic section 15

Clear l. 35

Clevenger, G. H. 306, 319

Cochrane s. mine.
- Plan of levels *In map case*
- Production 27

Cohen, S. W. 103, 106, 113

Coignac (guide) 357

Cole, A. A. 320, 322

Coleman, A. P. 331-334

Collins, E. A. xii, 124

Collins, H. F. 346

Collins, W. H. 333
- Classification by, of rocks of Northern Ont. 336, 350
- Views on Huronian of Gowganda area 342

Colonial s. mine.
- Development promising 2
- Diabase 34
- Flow-sheet *facing* 274
- Mine workings 170
  - plan of levels *In map case*
- Ore shoot, depth 5
- Silver, from contacts 7
  - production 25, 170

Columbus s. mine 36
- Plan of levels *In map case*

Colvocoresses, G. M. 335

Comfort Mining and Leasing Co. 228

Comstock, Nev., silver production 29

Concentrates, flotation.
- Comparative returns 304, 305

Concentrates, shipments 265

Concentration. *See* Gravity concentration.

Conglomerate 30, 31
- *See also* Cobalt series.
  - Timiskaming series.
- Main source of calcite 329
- Sketch, ideal 16

Coniagas silver mine.
- Conglomerate 56
- Development and geology 82-86
- Fault 13
- Flotation process 243, 297-302
- Flow-sheets 269-272, 274, *facing* 274, 276, 278
- Low-grade ore developed 2
- Mill, crushing costs 261
  - details 255-257
  - photo 273
  - practice 268
  - production chart 276
- Plan of levels *In map case*

PAGE

- Coniagas Silver Mine—*Continued.*
  - Shaft house, photo 273
  - Silver production 19, 23
- Coniagas Mines, Ltd.
  - *See also* Ruby s. m.
    - Trethewey s. m.
  - Beaver s. m. leased by 145
  - Capital; dividends 20, 82
  - Princess s. m. optioned to 186
  - Properties held by 82
- Contact fault.
  - Buffalo s. m. 67, 68
  - Cobalt Townsite s. m. 80
  - Coniagas s. m. 84-86
  - Princess s. m. 98, 99
- Contacts.
  - Influence of, on deposition of ore-shoots 8-10
- Cook tp. 40
- Cooke, H. C. 351
- Cooper, Wm. 138
- Copper 35
  - *See also* Flin Flon c. m.
  - Sudbury dist., age of deposit 338
  - Temiskaming s. m 132
  - Ural mtns 348
- Copper pyrites.
  - Green-Meehan, Red Rock, and Ruby mines 177, 179
  - Nipissing s. m. 55, 62
  - Oxford, Cobalt, and Victory mines 184
  - T. C. claim 236
- Copper Cliff, Ont. 305
- Corkill, E. T. xii
- Cosalite 36
- Cost of mining and milling.
  - Buffalo s. m 64
  - Coniagas s. m. 82
  - Crown Reserve s. m. 101, 102
  - McKinley-Darragh-Savage s. m. 113, 114
  - Nipissing s. m. 44
  - Seneca-Superior m. 156
  - Temiskaming m 133
- Coste, Eugene 329
- Cottrell precipitation system 244, 312, 313
- Couchiching series 348
- Courier, J. M. 358
- Crews-McFarlane s. mine 28
- Crompton s. mine 63
  - Description and workings 219-224
  - Location 203
  - Plan showing levels *In map case*
  - Wood's vein, production 194
- Cross lake.
  - Faults, notes and diagram 13, 14
  - Rocks 334
- Crown Reserve s. mine.
  - Coating of secondary origin on walls 127
  - Costs; mill returns 102
  - Development and geology 104-113
  - Diabase 34
  - Dump, photo 33
  - Faults 14
  - Gold 106
  - Levels, plan of *In map case*
  - Quartz-gabbro, analysis 109
  - Royalties paid 22
  - Section, vertical, coloured *facing* 34
  - Silver production 19, 23, 105
  - Sulphur 310

- Crown Reserve s. mine—*Continued.* PAGE
  - Veins, Big Chamber 89
    - location 11
    - productive below diabase 34
- Crown Reserve Mg. Co.
  - *See also* Carson vein.
    - Drummond Fraction m.
    - Silver Leaf m.
  - Capital; dividends 20, 101
- Crusher silver vein, production 88
- Crushers and crushing 242
  - Methods and costs 253-263
- Crystallization.
  - Notes by Spence 353, 354
- Culver, F. L. 146, 150
- Curry s. mine 228, 229
- Cyanicides 248
- Cyanidation.
  - Early and modern practice 241-251, 277-297
  - Suitability of the ores 248
- Cyanide tailings, flotation of 303

D

- Daigle, Alex 134
- Darragh, Ernest J. 331
  - *See also* McKinley-Darragh-Savage.
- Dawson pt. 338
- Deloro, Ont. 277
- De Lury, J. S. 330
- Denny, James J. xi, 290, 292, 319
  - Paper by, on Mg. and Metallurgical practice 241-320
- Depth of ore shoots 5
- Desulphurization 290
- Dewey, Alvin H 156
- Deyell, Harold J 318
- Diabase 30, 31
  - *See also* Geol. of mine workings, Nipissing diabase.
  - Fabre tp., Que 333
  - Gowganda area 336, 351
  - Origin of the ores 329
  - Silver production to 1911 335
    - dependent on proximity to 37
  - Thickness of sheet 2
  - Veins in, productive, number of 333, 335
- Diabase mt.
  - Ore bodies 157
  - Photo 33
  - Rocks 152
- Diabase-pegmatite 331
- Diamond-drill holes.
  - Plan of, in Watash m 186
- Diarsenides.
  - Order of deposition 340
- Dickson, Gordon F 128
- Dies and shoes.
  - Coniagas and Nipissing mills 261, 262
- Dividends 20, 21
- Dobbins, W. J 318
- Dodd, J. D 235
- Dolomite 35, 37
  - Haileybury (near), fossiliferous 338
- Dominion s. mine, production 25
- Dominion Reduction Co.
  - Cyanidation 277
  - Filters 291
  - Flotation process 297
  - Flow-sheets *facing* 274, 276
  - Pan amalgamation 250
  - Silver production 25
  - Zinc precipitation 291, 293
- Doré series 350

PAGE
Drummond, W. H 158
Drummond s. mine.
  Geology; development; production . 24, 158
  Productive veins below diabase 34
Drummond Fraction s. mine 26, 170
Dust precipitation. *See* Cottrell system.
Dye, Robert E 320
Dyscrasite 35, 246
  Cyaniding of 249

E

Edwards and Wright, Ltd 174
  See also Red Rock m...
Edwards-Wright s. m 7
  See also Green-Meehan m.
Elk lake, cosalite 36
Ellipsoidal basalt 30
Ellsworth, H. V 36, 339
Emens, Warren H 11, 65, 71, 73
Emmons, S. F.
  On origin of the ores 38
Emplecite 35, 246
Enargite 349
Englehart, Ont 339
Ennis, R. J 132
Eozoic. *See* Pre-Cambrian.
Epsomite 36
Erythrite. *See* Cobalt bloom.
Espanola greywacké and limestone 350
Everett s. m 28
Exhibition of minerals.
  Nipissing refinery, photo 245

F

Fabre series 334
Fabre tp., Que 333, 334
Fairlie, M. F 320
Fancy, W. F 65
Farmers Bank 204
Farr isld 338
Fault breccia. *See* Breccia.
Fault No. 64.
  Age; location; displacement; productive 10-17
  La Rose m 94, 95
  Nipissing m 51
Faults.
  See also Fault No. 64.
    Geol. of mine workings.
  Affecting deposition of ores 3, 10
  Character 342
  Description and notes 12-17
  Hudson Bay m 143
  Miller's views 334
  Plan of general outline and approximate position on surface 14
  Relationship to veins 16
    Nipissing m., sketch 51
  Silver in 12
  South Lorrain tp 194, 195
  Whitman's views 340
Feldspar, James tp 331
Feldspar porphyry.
  South Lorrain tp 196
  Temiskaming m., dike, notes and sketch 139
Felsite, Sasaginaga l 40
Ferric and ferrous ore.
  See also Iron formation.
  Keeley m., analysis 209
Ferrier, Miss D xii
Filters and filter presses 291
Fines, screening out 272

Fire of 1922. PAGE
  Haileybury after, photo 207
Fisher, Norman R 131, 135, 230
Fisher-Eplett s. mine 101
  See also La Rose Mines, Ltd.
Fleming s. vein 88-91, 105, 106
Flin Flon copper m., Man 63
Flotation process.
  Description and practice 243, 297-305
  Economic crushing limit for 256
  Ore suitability 251
Flow-sheets.
  Buffalo m .... 274, *facing* 274, 276; 312
  Cobalt Central m 274
  Cobalt Red. Co. *facing* 274, 276, 278; 286, 288, 314
  Coniagas m .... 269-272, 274, *facing* 274, 276, 278
  Early practice in batteries 267
  Flotation, general practice 268, 299
  McKinley-Darragh-Savage m. 264, *facing* 264; 274, *facing* 274, 276
  Nipissing m .... 258, *facing* 274, 276, 278, 280; 284, 285, 308
  O'Brien m .... *facing* 274, 276, 278; 279
  Various mines, comparative .... 274, *facing* 274, 276, 278
Fluorite 35, 338
Flynn, F. N 318
Folds and folding 32
  See also Geol. of mine workings.
  Whitman's views 340
Foreign silver fields 1
Formation tables.
  Cobalt s. area 326
  Gowganda s. area 336
  Matachewan area 351
  Northern Ontario 350
  S. Lorrain tp 196
Forneri s. mine.
  Acquired by Mg. Corp. of Can 219
  Rocks; workings 234, 235
Foster s. mine.
  Mine workings, photo 165-167
  Plan of levels .... *In map case*
  Silver production 25
  Veins productive below diabase 34
Foster Cobalt Mg. Co.
  Capital; dividends 20, 165
Fourth-of-July s. vein 47, 49, 57
Freiberg, Germany 29
Freibergite 35, 246, 251
Freieslebenite 246, 251
French, Herbert J 319
Frontier s. mine.
  Description; geology; history; photo; and workings 219-224
  Diabase 199
  Fault 194, 195
  Location, plan showing 203
  Minerals, list 352
    niccolite and smaltite 332
  Ore bodies along contact 231
    discovery 195
    origin 38
    structural position 130
  Owners 63
  Plan of levels .... *In map case*
  Veins, notes by Bastin 352
  Vertical section, coloured .... *facing* 219
Fume precipitation 312
  See also Cottrell system.

G

PAGE

- Galena.
  - Buffalo s. m. 67, 69
  - Crown Reserve s. m. 109
  - Deposition, order of 338
  - Frontier s. m. 352
  - Gowganda s. area 336
  - Nipissing s. m. 50, 51, 55, 62
  - O'Brien s. m. 124, 125
  - Oxford Cobalt and Victory s. m's. 184
  - Violet s. m. 97
- Galena fault 13
  - Buffalo s. m. 17, 67, 69
  - City of Cobalt s.m 72, 73
- Gans silver claim 135
- Gear silver vein, production 105, 106
- General Examining and Development Co.
  - *See also* Buffalo s. m.
  - Cost of mining 64
- Genesee s. mine.
  - Chert 35
  - Development promising 2
  - High-grade ore 10-13
  - Workings 181-183
- Geology.
  - General 30-34
  - Literature 321-358
  - Map . . . . . *facing* 30
  - Mine workings 43-187
  - South Lorrain tp 196-202
    - plan showing . . . . . *In map case*
  - Surface 40
- Germany. *See* Freiberg.
- Gersdorffite 349
- Gibson, Thomas W. xi
  - Account by, of first s. discoveries 331
- Gillespie, George H. 318
- Gillies limit, profit tax 22
- Giroux lake, photo 166
  - *See also* University s. m.
- Giroux s. mine 237
- Glaciation 31, 327
- Glen lake.
  - Photos; rocks 157, 166
- Glen Lake s. mine, production 27
- Globe, A. P. 318
- Gneiss 30
  - Northern Ont., notes by Collins 350
- Gold.
  - Agaunico s. mine 185
  - Age of deposition 338
  - Associated with cobaltite 246
  - Crown Reserve s. m. 106
  - Fabre tp 334
  - Porcupine area 338
- Goodwin, George 358
- Gouge, definition 12
- Gould Consolidated. *See* Mercer Mg. Co.
- Govt. revenue. *See* Revenue.
- Gowganda formation.
  - Age and composition 350
- Gowganda silver area.
  - Diabase, description 351, 352
    - relation to silver 8, 10
  - Formations, table of 336
  - Huronian, Collins' views 342
    - producing veins in 335
  - Map, index x
  - Silver production 18, 28
  - Upper contact, silver from 7

PAGE

- Granite 30, 31
  - *See also* Lorrain granite.
  - South Lorrain tp 196
- Granodiorite.
  - Crown Reserve s. m. 108
  - Gowganda area 336
- Graphite 35
  - La Rose s. m. 330
- Graphite shale, Gowganda area 336
- Gravity concentration.
  - Early and modern practice 265-276
  - Low-grade ore, notes 242
  - Suitability of the ores 246, 247
- Gravity stamps.
  - Economic limit 254
  - *See also* Stamp mills.
- Green-Meehan s. mine.
  - *See also* Edwards-Wright s. m.
  - Diabase sill 174
  - High-grade ore 13
  - Production 26, 174
  - Workings, notes, plan and section . . 174-177
- Greenstone. *See* Keewatin.
- Grenville series 30
  - Iron formation deposit in 338
  - Matachewan area 351
- Greywacké 30, 31, 40
  - Overlying conglomerate, sketch 11
- Groch, Frank 320
- Guanajuato, Mexico, s. production 1, 29

H

- Haileyburian formation 31
  - Age and ores 344
  - Frontier s. m. 221
  - Keeley s. m. 216
  - Matachewan s. m. 351
  - New Liskeard, section 15
  - *See also* Lamprophyre.
- Haileybury.
  - Photo, after the fire 201
  - Rocks 32, 325, 338
- Haileybury Silver claim.
  - *See also* Frontier mine.
  - Smaltite and niccolite 372
  - Vein 224
- Hailey Silver Mg. Co. 220
- Hamilton, E. M. 292
- Hancock, R. T. 346
- Hardinge mills 253, 254
- Hardman, J. E. 327
- Hargrave s. mine.
  - Development 92, 93
  - Plans of levels . . . . . *In map case*
  - Royalties paid by 22
  - Silver production 25, 92
- Harkness, J. G. 190, 220, 234
- Harris, Mark. *See* Lorrain Consolidated.
- Harris s. mine 203
- Harvie, Robt 334
- Helen iron mine 193
- Henderson, J. A. L. 346
- Heterogenite 35, 324
- Heubachite 35
- High-grade ores, treatment of 263-305
- Hill, David . . . . . xii, 65
- Hill, James . . . . . xii, 65, 120, 173, 178
  - Description of Cobalt Townsite m. 78
  - La Rose m., mapped by 93
  - Notes on Buffalo m. 66
  - Views on Cobalt series 81
- Hixon, A. B. 329

PAGE
Hixon, Hiram W. ... 318
Hopkins, P. E. ... 348
Hore, R. E. ... 319, 330-335
Hornblende granite and schist.
  Gowganda area ... 336
Howe, Henry M ... 318
H. R. loc. 14 ... 235
H. R. locs. 30, 61 ... 201
H. R. loc. 56 ... 236
H. R. loc. 98 ... 202
H. R. loc. 103, fault ... 194
H. R. loc. 113 ... 199
H. S. loc. 11, rocks ... 231
H. S. loc. 308 ... 201
H. S. locs. 497, 500 ... 199, 236
Hudson Bay s. mine.
  Faults ... 14, 50, 51, 346
  Flow-sheets ... *facing* 274, 276
  Iron formation ... 166
  Mine workings ... 142-144
    plan of levels ... *In map case*
  Royalties paid by ... 22
  Silver production ... 19, 24, 142
  Vein No. 64 ... 47
Hudson Bay Mines, Ltd.
  Capital; dividends ... 20, 142
  Properties in Leith tp., s. production ... 28
Hughes, Ben ... 319
Hume, G. S. ... 195, 339, 343
  Description by, of L. Timiskaming fault ... 15, 16
Huronian.
  Composition ... 326
  Contact with Keewatin, notes ... 341
  Joints in, favourable for ores ... 340
  Northern Ontario.
    classification ... 350
    Gowganda s. area ... 335, 336
Huronian, Lower. *See* Cobalt series.
Huronian slate ... 323
Hutchison, R. H ... xi
  Paper by, on Metallurgical Practice ... 241-320
Hyberville, Sieur de ... 356, 357
Hydrated oxide of cobalt ... 324
Hypochloride-cyanidization process ... 244, 250, 315, 316

I

Ingall, Elfric Drew ... 325, 329
Intermediate crushing ... 253
Iron.
  Cobalt ores, S. Lorrain tp ... 191
Iron diarsenide. *See* Löllingite.
Iron formation ... 30, 31, 40
  See also Geology of mine wkgs.
  Age of deposition ... 336-350
  Geological notes ... 34, 35
  Gowganda area ... 336
  Influence of, in formation of vein fractures ... 18
  Timagami lake ... 326
Iron pyrites. *See* Pyrite.

J

James tp., silver, origin ... 331, 332
Jasper ... 326
Jaspilite. *See* Iron formation.
Jaw crusher ... 253
J. B. loc. 1.
  See also McKinley-Darragh-Savage m.
  First Cobalt discovery ... 331

PAGE
Johnston, Frank ... 319
Joint planes, silver production ... 16
Jones, T. R ... 186
Jowsey, R. J ... 206, 207
  Account by, of discovery, Keeley m ... 218
  Original owner, Keeley m ... 202
  Photo ... 198

K

Kee, A. H ... 41
Keeley, Charles ... 202
Keeley s. mine.
  See also Wood's vein.
  Calcite, analysis ... 215
  Cobalt ore, analysis ... 191
  Diabase, dip ... 199
  Discovery ... 190
  Fault ... 194, 195
  Glaciation ... 31
  History ... 202
  Location, plan showing ... 203
  Mica lamprophyre, analysis ... 216
  Notes by J. M. Bell ... 344, 345
  Ore, discovery ... 195
    origin ... 38, 40
    shoots ... 193
    structural position ... 130, 231
    superficial alteration ... 348
  Photos of mine and mill ... 205, 212, 219
  Pre-glacial weathering ... 3, 208, 353
  Section, vertical, coloured ... *facing* 207
  Silver, production ... 190, 192
    secondary ... 210
  Stope section on Wood's vein ... *facing* 216
  Vein No. 26, production ... 194
    and rock structure ... 207
  Workings, description ... 210-218
    original, photo ... 237, 332
    plan of levels ... *In map case*
Keeley Mine, Ltd ... 204
Keeley Silver Mines, Ltd ... 191
  Beaver L. claims acquired by ... 217
  Capital ... 202
Keewatin formation.
  See also Geology of mine wkgs.
  Age; composition ... 30, 31
  Calcite in ... 329
  Cobalt series in, ideal sketch ... 11
  Contact with Huronian, notes ... 341
  Gowganda area ... 336
  Lava flows, notes ... 40
  Matachewan area ... 351
  Notes by Collins ... 337, 339
  Ore bodies in, near diabase contact ... 340
  Relation of, to contact fault ... 83
  Silver minerals in ... 246
    relation to ... 5, 7, 10
  South Lorrain tp ... 196
Kell s. mine ... 28
Kendell s. vein (No. 63) ... 57-62, 118, 120
Kerr lake ... 14
  See also Drummond s. m.
    Drummond Fraction s. m.
  Diabase dome, notes and photo ... 32-34
  Emptied ... 107
    photo after being ... 33
  Stopes in bed of, photo ... 87
Kerr Lake s. mine.
  Bonanzas ... 38
  Löllingite ... 191
  Plant and dump, photos ... 33, 244

Kerr Lake s. mine—*Continued.* PAGE
  Silver from contact.................. 10
    production..................19, 23, 88
  Sulphur.............................. 310
  Veins, calcite....................... 158
    Fleming.....................106, 111
    location.......................... 11
    No. 3, length of stope............ 193
    productive below diabase.......34, 193
  Workings..........................89-93
    plan of levels.............*In map case*
Kerr Lake Mines, Ltd.
  See also Drummond Fraction s. m.
    Hargrave s. m.
  Capital; dividends................20, 82
  Profit tax........................... 22
Kerry Mining Co........................ 152
Keweenawan...............30-32, 326, 337
  L. Superior dist..................... 336
  Northern Ontario.
    classification..................... 350
    Matachewan area.................... 351
    S. Lorrain tp...................... 196
  Ore deposits......................16, 338
Killarney granite and gneiss........... 350
King, Neil A........................... 331
King Edward s. mine.
  Diabase.............................. 34
  Flow-sheet..................*facing* 274
  Silver from upper contact............ 7
    production......................... 25
King George s. claims.................. 236
Kirk l., rocks......................... 334
Kirkland Lake area.
  Formations, table of................. 350
  Map, index........................... x
Kirkland Lake Gold Mg. Co.............. 146
Kirkpatrick, S. F...................... 292
Knight, Cyril W..............327-335, 338
  Classification by, of Pre-Cambrian, Ont.......... 339
  Name Haileyburian suggested by....... 344
  Notes on structural geology.......... 346
  Views on Grenville series............ 336
Knittel, C. A.....................36, 347
Knox, Henry H.......................... 348
Kupfer-Nickel. *See* Niccolite.

L

Labradorean ice sheet.................. 31
Lake Huron area, Animikean............. 339
Lake North (No. 3) s. vein, production. 88
Lake s. vein, McKinley-Darragh-Savage mines.....................118, 119
Lake Superior, silver.................. 325
Lake Timiskaming fault.........194, 195
  Age; description..................14, 15
  Hume's views......................... 343
Lallement, Sieur....................... 356
Lamprophyre dikes.................30, 31
  Adanac s. m.......................... 178
  Agaunico s. m........................ 185
  Age.................................. 337
  Beaver s. m..................69, 149, 151
  City of Cobalt s. m.................. 72
  Crown Reserve s. m...............104, 110
  Influence of, in formation of vein fractures.......... 18
  Kerr Lake s. m....................... 91
  McKinley-Darragh-Savage s. m...118, 121
  O'Brien s. m......................... 128
  S. Lorrain tp........................ 196
Lamprophyre dikes—*Continued.* PAGE
  Temiskaming and Trethewey s. mines.................130, 140, 141
Lang-Caswell s. m...................... 237
La Nove, Sieur de...................... 356
La Rose, Fred.......................... 331
La Rose silver mine.
  Faults..................13, 14, 17, 335
  Graphite............................. 330
  Silver production.............19, 23, 93
  Sulphur.............................. 310
  Workings..........................93-95
    plan of levels.............*In map case*
La Rose Extension s. m................. 95
La Rose Mines, Ltd.
  Capital; dividends................20, 93
  Properties........................... 93
Latour lake............................ 237
Laurentian........................30, 326
  Gowganda area........................ 336
  Matachewan area...................... 351
  Ore deposits eroded.................. 338
Lava...........................30-32, 40
  See also Geol. of mine wkgs.
  Gowganda s. area..................... 336
  S. Lorrain tp........................ 196
Lawson s. mine.
  See also La Rose s. m.
  Development and plan.............99, 100
  Photo................................ 166
  Silver production.................... 99
  Veins productive below diabase....34, 193
Lead.
  See also Galena; Wright m.
  Wright mine.......................... 321
Ledoux, Albert R....................... 350
Ledoux & Co.....................208, 209
Leith tp., silver production........... 28
Levels of mines, plans of.......*In map case*
  See also the various mines.
Lightning river........................ 40
Limestone, crystalline................. 30
Limonite, Keeley s. m.................. 216
  Nipissing s. m....................... 50
Lindgren, Waldemar..................... 12
Literature.
  See also Bibliography.
  Geology, etc., paper by C. W. Knight.....................321-358
Little Keeley s. claim................. 233
Little McDonald s. claim, production... 88
Little Nipissing s. mine.
  Plan of levels..............*In map case*
  Production; work.................26, 177
Little silver shaft.................... 154
Little silver vein...............57-62, 88
Livermore, R........................... 338
Lockport formation..................... 339
  New Liskeard, section................ 15
Logan, Sir William...............321, 323
Loganian period........................ 30
  See Grenville and Keewatin.
Löllingite...................36, 191, 352
Long lake.
  Rocks; silver ores......195, 201, 323, 324
Loon lake, fault....................... 194
Lorrain granite.
  Age..............................326, 339
  Beaver s. m.......................... 150
  Definition........................... 334
Lorrain syndicate. *See* Pittsburgh-Lorrain.

PAGE

Lorrain tp.
  Rocks; silver mg. 237, 337
Lorrain Consolidated s. m. 199, 233, 234
Lorrain Trout Lake Mines claim. 238
Lorrain series.
  Age. 326, 337
  Gowganda area. 336
  Intruded in Cobalt series. 350
Lower contact, percentage of silver from. 7
Low-grade ores, treatment of. 263-305
Lumsden s. mine.
  Silver from upper contact. 7
    production. 27, 178
  Workings. 178
    plan of levels. . . . .*In map case*
Lyman, R. H. 156

M

McCarthy, E. T. 346
McDonald s. vein. 88, 94, 122
McIntyre gold mine. 354
McIntyre Porcupine Mines, Ltd. 128
McKinley, James H.
  See also McKinley-Darragh-Savage.
  Discoverer, Cobalt field. 331
McKinley-Darragh-Savage s. mine.
  Costs of mining. 113, 114
  Discovery. 331
  Faults. 13, 16, 93, 335
  First mine applied for. 93
  Flotation process. 297
  Flow-sheets. . . . . .264, *facing* 264; 274, *facing* 274, 276
  Mill, photo. 252
    practice. 263-265, 274-276
  Photo, Cobalt lake fault. xiv
  Section, vertical, coloured. . . . . .*facing* 12
  Silver production. 19, 23, 113, 115
  Workings. 114-119
    plan of levels. . . . .*In map case*
McKinley-Darragh-Savage Mines of Cobalt, Ltd.
  See also Savage s. m.
  Capital; dividends. 20, 113
McMillan, J. G. . . . . .xii, 123, 124
McNeill, W. K.
  Analyses and tests by,
    36, 109, 127, 191, 210, 216, 229, 230, 234
McRae, J. A. 321
  Account by, of Wright mine. 356-358
McReavy, I. S. 132, 133
MacVichie, J. A. 184
Magnetite. 338
Maguire, T. D. 156
Maidens s. claims.
  Description; plan; wkgs. 230-233
  Location, plan showing. 203
Maidens Silver Mg. Co. 233
Maidens valley.
  Fault, rocks. 194, 197, 198
Main East s. vein, production. 88
Mann isld. 338
Mann s. mine. 28
Maple Mount s. claim, production. 18
Maps and plans. 4, 5, 196
  See also the various mines.
  Cobalt s. a., geological. . . . .*facing* 30
    index. x
  Mine levels. . . . .*In map case*
  S. Lorrain tp., mg. claims. 203

PAGE

Maricourt, Major. 356
Martin, E. 110
Matachewan area.
  Pre-Cambrian, classification. 351
Matachewan formation. 30, 322
Matildite. 35, 246
  Flotation treatment, extraction. 251
Megraw, Herbert A. 318, 319
Mercer s. mine.
  Ore; production. 154
Mercer Mining Co. 177
Mercury. 35, 37
  Keeley s. m. 210
  Means to recover. 244
  Nipissing s. m. 309, 310
Metallurgical practice.
  Paper by Reid, Denny and Hutchison. 241-320
Mexico, silver production. 29
Meyer shaft, photo. 73
Meyer vein.
  Development on. 52-56
  Ore shoot, diagram. 8, 9
  Production, estimated. 47
  Relation between, and fault, sketch showing. 48
  Stope, length of. 193
Mica-lamprophyre. 211, 215, 216
Michipicoten isld. 325
Mickle, G. R. 7, 333, 335
Middling, treatment of. 275, 298
Miller, Willet G.
  Acknowledgments to. xi
  Classification by, of rocks
    326, 337, 339, 351
  Cobalt series named by. 334
  Letter to, *re* re-survey of area. 41
  List by, of minerals. 35
  Report by (first), on area. 322-325
  Timiskaming L. fault described by. 15, 195
  Views of, on :—
    disappearance of silver in Keewatin 7
    faults. 12, 334
    Grenville series. 336
    origin of ores. 36, 329
Miller Lake O'Brien s. mine. 28
  See also Millerett s. m.
  Diabase; s. production. 19, 335
Millerett s. mine, Gowganda. 28
  Huronian. 335
  Silver above diabase. 8
    from Cobalt series. 348
Millerite. 35, 246
Milling costs. *See* Costs of mining.
Milling practice.
  Bibliography. .318-320
  Paper, by Reid, Denny and Hutchison. 241-320
Mine fines, screening out. 272
Mine levels. *See* Mine workings.
Mineralogy. 35, 36
Minerals.
  Photo of exhibit at Cobalt. 245
Mines.
  Description and geology. 43-238
  Levels, plans of. . . . .*In map case*
    notes. 4
  Producing, number of. 265

Mining Corporation of Canada, Ltd. PAGE
  See also Buffalo s.m.
    City of Cobalt s. m.
    Cobalt Lake s. m.
    Cobalt Townsite s. m.
    Crompton s. m.
    Foster s. m.
    Frontier s. m.
    Townsite Extension s. m.
  Acknowledgments to 191
  Capital; dividends 21, 63
  Cart and Peterson lakes leased by 171, 177
  Claims acquired by 221, 233, 234, 238
  Geology of mines 64-81
  Silver production 23, 63
  Work by, on:—
    Little Nipissing m.
    Seneca-Superior m.
Mining costs. *See* Costs of mining.
Mining revenue and silver production 22-27
Mispickel 35, 325
  See also Arsenopyrite.
Mississagi quartzite 350
Monarsenides 340
Monte Cristo m., Arizona 349
Montreal River area, production 18
Montreal River fault 194, 195
Moose Horn s. m 36
Mulligan tp 348
Murray, Alexander 323
Mutch, Douglas 132

N

Nancy-Helen s. mine 26, 27
National silver mine.
  Flotation process 297
  Flow-sheet *facing* 276
  Silver production 25
Native silver.
  See also Geology of mine wkgs.
  Percentage of, in production 246
Neilly, Balmer xii, 132, 156, 157
Net Lake 325
Nevada. *See* Comstock.
Newburger, Henry 220
Newburger, Joseph 220
New Caledonia, nickel 325
New Liskeard 32, 339
  Vertical section through, diagram 15
Newman s. mine. *See* Bellellen s. m.
New South Wales, cobalt ores 325
Niagara formation 326, 337, 338
Niccolite 35
  Age of deposition 327, 339
  Agaunico s. m 185
  Arizona 349
  Beaver s. m 149
  City of Cobalt and Cobalt Lake s. m's 66, 77
  Composition, theoretical 323
  Continuous below contact 329
  Cyanidation of 248
  Discovery, first 331
  Drummond s. m 158
  Frontier s. m 221, 332, 352
  Gowganda s. area 336
  Keeley s. m 218
  Lorrain Consolidated s. m 233
  McKinley-Darragh-Savage m 120
  Mistaken for copper 322, 331
  Nipissing s. m 50, 51
  Port Arthur dist 325
  Stratification order, in milling 275

Niccolite—*Continued.* PAGE
  Temiskaming s. m 135-138
  Veins, varying value 247
  Victory s. m 184
  With native silver 246
Nickel.
  Age of deposition 338
  As a cyanicide 315
  Discovery in area 323
  Fisher-Eplett s. m 101
  Michipicoten isld 325
  Percentage in ores 330
  Silver Queen s. m 162
  South Lorrain tp 191
  Sudbury dist 324
Nickel bloom. *See* Annabergite.
Nickel minerals.
  Origin of, in Cobalt veins 37
Nickel sulphide 35
Nipissing diabase.
  See also Diabase.
    Geology of mine wkgs.
    Kerr l.
  Age 337
  Keeley m., analysis 213
  Named by Miller 321
  Ore shoots associated with 8, 122
  Origin of silver ores 36, 343
  Silver in, percentage proportion to other rocks 7
  S. Lorrain tp 196-201
    vertical section *facing* 207
  Thickness 34
Nipissing hill, rocks 341
Nipissing s. mine.
  See also Meyer s. vein.
  Costs; reserves 44, 45
  Cyanidation 242, 243, 249, 250, 272-285
  Desulphurization 290, 291
  Diabase sill, section 174
  Faults 5, 17, 346
  Filters 291
  Flotation plant 297, 303
  Flow-sheets 258, *facing* 274, 276, 278, 280; 284, 285, 308
  Greywacké 154
  High-grade ore, treatment 305-310
  Hypochlorite treatment 315
  Location, plan showing 17
  Mercury 244, 309
  Mill, photo 282
    practice 255-294
  Ore sold, value 348
  Photo 42
  Section, vertical, coloured *facing* 12
  Silver production 19, 23, 42
  Sphaerocobaltite 36
  Sulphur 310
  Tilting retort, diagram 309
  Vein crystallization 353
  Workings 45-62
    plan of levels *In map case*
Nipissing Mines Co.
  Capital; dividends 21, 44, 348
Nipissing Reduction Co.
  Flow-sheet *facing* 274
Norite 30, 336
North silver vein 105, 106
North Cobalt, fault 40
North Cobalt s. mine.
  Diabase 34
  Production 27

North Cobalt s. mine—*Continued.* PAGE
  Workings and plan 180
Northern Customs Concentrators, Ltd.
  Flotation process 297
  Flow-sheets .... *facing* 274, 276
Northern Mines xii
Nova Scotia s. mine.
  Cyanidation 277
  Location, plan showing 171
  Silver production 25
Nuggets 330

O

O'Brien s. mine.
  Cyanidation 242, 249, 277
  Diabase sill, section 174
  Faults 14
  Filter 291
  Flow-sheets .... *facing* 274, 276, 278; 279
  Geology and workings 121-128
    plan of levels .... *In map case*
  Iron formation 96
  Location, plan showing 171
  McDonald vein 94
  Milling and concentrating 255, 257, 274-279
  Royalties paid by 22
  Silver from lower contact 7, 10
    production 19, 24, 121
  Sodium sulphite process 294
  Stope (No. 1 vein), length 193
  Treatment of precipitate 294
Office silver vein 91
Oil mixture for flotation 243, 297, 298
Olivine diabase 336
Onaping area, Huronian 342
Onaping tuffs 350
Ontario.
  Geol. formations in N.E. 30
  Pre-Cambrian classification 339
    metal prod 344
Onwatin slate 350
Ophir s. mine 187
Ordovician 30
  See also Haileyburian.
  Northern Ont 350
Ores and ore deposits.
  Age classification 338
  Characteristics 246
  How they occur 5-21
  Mining and treatment of 241-320
  Origin 36, 327, 328
  Reserves 18
    difficult to estimate 131
  Suitability for treatment 246-252
Ore shoots.
  Associated with Cobalt series 7-10
  Depth 5
  Factors governing formation of 8-11
  Notes by J. M. Bell and Whitehead 343, 355
Oxbow lake, rocks 195, 202
Oxford Cobalt Silver Mines, Ltd 1,183
Oxides 35

P

Pachuca, Mexico 29
Paleozoic 30, 31, 322
  See also Niagara formation.
  Northern Ontario 350
Palladium 36, 347
Palmer, Chase 37, 335

PAGE
Pan-Silver s.m. 177
Park, Hugh 36, 47
Parks, W. A. 326, 329
Parsons, A. L. 193
Pearceite 349
Pegmatite 332
Penly, Walter J. D. 191, 236
Penn-Canadian s. mine.
  Flow-sheets .... *facing* 274, 276
  Geol. and wkgs.
    plan of levels .... *In map case*
  Photo 157
  Silver production 24
  Vertical section, coloured .... *facing* 40
Penn-Canadian Mines, Ltd.
  Capital; dividends 21
People's silver mine 187
Peterson lake.
  See also Little Nipissing m.
    Seneca-Superior m.
  Conditions of erosion and deposition beneath 172
  Fault near 60
  Leased by Mg. Corporation 63, 171, 177
  Map 168, 169
  Mine workings under, plan of 2
Peterson Lake s. mine.
  See also Seneca-Superior m.
  Silver production 25, 167
Peterson Lake Silver-Cobalt Mg. Co.
  Capital; dividends 21
  Contract with Seneca-Superior m 152
  Leases, map and plan 168-171
Petroleum Oil Trust 358
Phosphate 35
Pittsburgh-Lorrain Syndicate.
  Operating Curry and Wettlaufer mines 228, 229
  Production 192
Plans of mines .... 4 and *in map case*
Pleistocene 30, 31
Polybarite 35, 246
Pontiac series 350
Porcupine gold area.
  Age of deposition 338
  Formations, table of 350
  Influence of wall-rock 354
  Lava flows 32
  Map, index x
Porphyry 30
Port Arthur 325
Post, W. J 161
Potosi, Bolivia, s. production 1, 29
Powerful s. mine 28
Pre-Cambrian.
  Cobalt s. area 30, 31
    classification 337
    faulting 16
    metallogenetic epochs 338
    New Liskeard, section 15
    S. Lorrain tp 196-202
  Gowganda s. area, classification 336
  Matachewan area, classification 351
  Ontario, classification 339
  Potential wealth 1
Precipitation (cyanidization) 291-294
Pre-glacial weathering 3
Price of silver 18, 29, 281
Prince s. mine.
  Development 186
  Levels, plan of .... *In map case*

Prince s. mine—*Continued.* PAGE
  Optioned to Beaver m.............. 149
Profit tax.......................... 22
Proustite.........................35, 241
  See also Ruby silver.
  Arizona........................... 349
  Flotation treatment, extraction...... 251
  Frontier m........................ 352
  Keewatin formation................ 246
Provincial s. mine.
  Greywacké....................172-174
  Location, plan showing............. 171
  Royalties paid by................22, 26
  Silver production.................. 172
  Workings.....................172-174
    plan of levels............*In map case*
Pugsley, F. W....................... 318
Pyrargyrite.......................35, 241
  See also Ruby silver.
  Flotation treatment, extraction...... 251
  Keewatin formation................ 246
Pyrite.............................. 35
  Beaver s. m...............147, 151, 152
  Buffalo s. m....................... 69
  Cobalt Townsite m.................. 81
  Frontier m........................ 352
  Gowganda s. area.................. 336
  Hudson Bay m.................143, 144
  Kerr Lake m........................ 90
  Nipissing m.......................50, 51
  O'Brien m....................124, 125
  Stratification order in milling........ 275
  Temiskaming m.................... 140
Pyrrhotite.
  Agaunico m....................... 184
  Sudbury dist..................323-325

Q

Quartz, auriferous.................. 185
Quartz diabase. *See* Nipissing diabase.
Quartz gabbro.
  Crown Reserve m., analysis......... 109
Quartz porphyry. *See* Keewatin.
Quartzite.........................30, 31
  See also Cobalt series.
  Gowganda area.................... 336
  S. Lorrain tp.................196, 197
Quicksilver. *See* Mercury.

R

Rabbit l., Timagami dist............. 326
Rammelsbergite...................... 36
Ramsay, J. B....................... 333
Ramsay Lake series................. 339
Rattray, J. H....................... 178
Redington, John............172, 173, 192
Red Rock s. mine..............175, 177
Reeve-Dobie s. mine................. 28
Reid, Fraser D...........xi, 48, 318, 319
  Paper on Mg. and Metallurgical
    Practice....................241-320
Reid, J. A.
  Views on origin of ores............. 342
Reliance s. mine, production.......... 26
Replacement deposits.
  Explanation of term 3
Retorting at Nipissing m..........308, 309
Revenue, mining..................... 22
Reverse faults.
  Cobalt area, none other............. 342
Rhyolite........................... 336
Richardson, Charles A............... 134

PAGE
Right of Way s. mine.
  Silver production...............19, 24, 159
  Workings......................159, 160
    plan of levels............*In map case*
Right of Way Mines, Ltd.
  Capital; development.............21, 159
Right of Way Mining Co.
  Capital; development................ 21
R. L. loc. 461...................197, 231
Robb, J. M.......................... xii
Robertson, John J................... 318
Rochester s. mine.
  Plan of levels..............*In map case*
  Silver from upper contact........... 7
    production....................27, 179
Rock ck........................... 331
Rogers, W. R....................xii, 330
Roll mills.......................... 267
Rose, Fred. *See* La Rose, Fred.
Roselite........................... 35
Ross, J. G., photo.................. 103
Ross silver vein.................105, 106
Royalties, mining.................... 22
Rubber liners for tube mills........... 263
Ruby silver.
  See also Proustite; Pyrargyrite.
  Keeley m......................210, 214
  Nipissing m......................39, 50
Ruby s. mine.
  Cobalt ores......................... 2
  Copper pyrites..................... 177
  Diabase sill, section................ 174
  Fault.............................. 40
  Lower contact....................... 7
  Silver production.................27, 179
  Workings.......................... 179
Russell, J. W....................183, 184

S

St. Anthony s. mine................. 171
St. Germain, Sieur de................ 356
St. Helen, Sieur de.................. 356
Sancton, G. E....................... 318
Sandstone. *See* Niagara formation.
Sasaginaga lake..............13, 32, 35, 40
Savage silver mine.
  Development and workings......120, 121
    plan of levels............*In map case*
  Greywacké........................ 154
  Location, plan showing............. 171
Scapolite.........................35, 352
Scorodite.......................... 246
Screen analyses.................255-257
Screening fines..................... 272
Secondary concentration..........328-330
Secondary enrichment.
  Notes by Bell, Miller and Emmons..37, 38
  Notes by Reid and Whitehead....342, 343
Secondary silver.
  Keeley m......................... 210
  Nipissing m........................ 50
Segsworth, W. F..............152-156, 177
Seneca-Superior s. mine.
  Depression in contact............... 341
  Geology and workings..........152-156
  Greywacké affects veins............ 118
  Location, plan showing............. 171
  Section, vertical.................. 153
  Silver production.................24, 155
  Worked by Mg. Corp. of Canada.... 177

PAGE
Seneca-Superior Silver Mines, Ltd.
  Capital; dividends ... 21
  Notes by Segsworth ... 152
Sericite schist ... 336
Serpent quartzite ... 350
Serpentine ... 30
Sharp Lake Mines, Ltd ... 235
Shaw, John ... 331
Shoes and dies, Coniagas mill ... 261
Short lake. *See* Little Nipissing s. m.
Silurian ... 30, 322
  See also Lockport formation.
    Niagara formation.
    Walsi formation.
  Northern Ontario ... 350
    Timiskaming l ... 15, 338
Silver.
  Arizona compared with Cobalt area. 349, 350
  Auld and Cane tps ... 348
  Deposition, order of ... 327, 338-340
  Depth, Cobalt area ... 148
  Gowganda s. area ... 336
  In faults ... 12
  James tp., origin ... 331, 332
  Michipicoten isld ... 325
  Ores. *See* Ores.
  Prices ... 18, 29, 281
  Quebec. *See* Wright m.
  Silver islet ... 325
  Statistics Cobalt area ... 18-27, 265
    Gowganda area ... 28
    World's ... 29
  Stratification order in milling ... 275
  World's great fields ... 1
Silver Islet ... 325
Silver, native. *See* Native silver.
Silver sulphantimonide ... 230
Silver sulphide ... 35
Silver veins. *See* Veins.
Silver Bar s. mine, production ... 27
Silver Cliff s. mine ... 7, *facing* 274
Silver Eagle s. mine ... 192, 229
Silver Leaf s. mine.
  Carson vein ... 113
  Depth; diabase ... 105, 110
  Production ... 25, 167
  Section through N. shaft ... *facing* 34
  Workings ... 167
    plan of levels ... *In map case*
Silver Queen s. mine.
  Plan of levels ... *In map case*
Simpson, W. E ... 320
Sizing, analysis ... 256
Skimmings, treatment of ... 295
Slate.
  See also Greywacké.
  Seneca-Superior m ... 152-155
Slate conglomerate ... 323
Slate fault ... 80
Slimes.
  Concentration ... 267
  Danger of ... 254
  Palladium and platinum in ... 347
Smaltite ... 35
  Beaver m ... 149, 343
  Bellellen m ... 229
  Buffalo m ... 69
  Chambers-Ferland m ... 162-164
  City of Cobalt m ... 65
  Cobalt Lake m ... 77
  Cobalt Townsite m ... 81

Smaltite—*Continued.* PAGE
  Composition, theoretical ... 323
  Coniagas m ... 85
  Continuous below contact ... 329
  Crown Reserve m ... 109, 110
  Cyanidation of ... 248
  Drummond m ... 158
  Frontier m ... 222
  Generally miscalled ... 352
  Gowganda s. area ... 336
  Keeley m ... 204, 214, 217
  Kerr Lake m ... 91
  Lorrain Consolidated m ... 233
  McKinley-Darragh-Savage m ... 118
  Maidens claim ... 332
  Mineralogical notes ... 324
  Native silver associated with ... 246
  Nipissing m ... 49-50, 354
  Origin ... 327, 328
  Oxford Cobalt m ... 183
  Princess m ... 98
  Provincial m ... 172
  Ruby m ... 180
  Seneca-Superior m ... 154
  Silver Queen m ... 161-164
  Taylor m ... 234
  T. C. claim ... 236
  Temiskaming m ... 135-138
  Veins, varying value ... 247
  Victory m ... 184
  Violet m ... 96
  Wettlaufer m ... 225, 226
Smelting ... 305
Smith, H. C ... 5
Smith, Leonard G., photos ... 188, 212
Sodium sulphide precipitation
  277, 281, 293, 294
South Lorrain tp.
  See also Frontier s. m.
    Keeley s. m.
  Agricultural land ... 190
  Diabase ... 34
    vertical section ... *facing* 207
  Discoveries upset prophecies ... 4
  Faults ... 12-17
  Maps, index and geological ... x, 189,
    facing 193
  Mines and mining ... 189-238
  Ore, high-grade ... 1, 2
    shoots ... 355
  Silver area productive, geol.
    plan ... *In map case*
    from upper contact ... 7, 10
    production ... 3, 18, 191, 192
  Veins, No. 10, production ... 88
    notes by Tyrrell ... 335
Specularite ... 336
Sphaero-cobaltite ... 36, 246
Sphalerite. *See* Zinc blende.
Split s. vein ... 88
Spurr, J. E ... 3, 353
Stafford, W. H ... 204
Stamp mills ... 253, 254
  See also Milling.
Standard s. mine, production ... 24
Statistics. *See* Silver production.
Steenman, L. F ... 181-183
Stephanite ... 35, 246
  Nipissing m ... 39, 40, 50
Stewart, R. B ... 190
Stromeyerite ... 35

PAGE
Strong, Horace F. 191, 194, 224, 226
  Interest in Keeley m. 190
  Notes by, on:—
    Frontier m. 220
    Silver Eagle m. 229
    Wettlaufer m. 225, 226
Structure of the rocks 31
  See also Geol. of mine workings.
Sudbury dist.
  Formations, table of 350
  Nickel and copper ores 323-325, 338
Sudbury series 339
Sulpharsenides 339, 340
  See also Arsenopyrite, Cobaltite, etc.
Sulphides and Sulpharsenides 35
Sulphobismuthites 35
Sulphur.
  Cobalt ores, S. Lorrain tp. 191
  Discovery in area 324
  Mines, various, percentage 310
Sulphuric acid-cyanidization process 250
Susquehanna s. mine 171
Sutherland, T. F. xii
Syenite 30, 196
Symplesite 36

T

Table concentrates, sampling of 296
Table feed, Coniagas m. 273
Table of formations. *See* Formations.
Tallen s. mine 235, 236
Taxes. *See* Royalties; Profit tax.
Taylor s. mine 234
T. C. locs. 71 and 73 . . . . 234, 236
Temiskaming. *See also* Timiskaming.
Temiskaming s. mine.
  Calcite 147
  Diabase 32, 34, 184
  Flow-sheets . . . . *facing* 274, 276
  Geol. and workings 129-140
    levels, plan of . . . . *In map case*
    stopes 146
  Historical notes 134
  Photos 145, 252
  Sections, vertical, coloured . . . *facing* 10, 32
  Silver from upper contact 7, 10
    production 19, 24, 128, 133
  Veins 10, 115, 147, 193
Temiskaming and Hudson Bay Mg. Co.
  Capital; dividends 21
Temiskaming and Northern Ontario Ry.,
    Cobalt discovery due to 332
Temiskaming Mine Managers' Association 41
Temiskaming Mg. Co.
  Capital; dividends 21, 128
Temiskamite 36
Tennantite 349
Tetrahedrite 35, 246, 352
Thessalon greenstone 350
Thornhill, E. B. 311, 319, 320
Thornhill process 244, 311
Thorold, Ont. 305
Tillite. *See* Boulder clay.
Tilting retort, diagram 309
Timagami lake 326
Timiskamian series 30-32
  Matachewan s. area 351
  Mineral deposits in 338
  Views of Miller and Knight 339
Timiskaming. *See also* Temiskaming.
Timiskaming lake.
  See also Haileybury.
      Wright m.
  Early knowledge and reports 321, 331
  Fault 15, 16
  Rocks 20, 32, 333-339
Timiskaming series.
  Age and composition 337, 350
  Later meaning of 334
Titaniferous magnetite 338
Toronto Lorrain Silver Mines, Ltd. 236
Tough-Oakes Gold Mines, Ltd. 161
Townsite s. m. *See* Cobalt Townsite m.
Townsite Extension s. mine.
  Owners; reserves; rocks 63, 64
  Workings, plan of levels . . . . . . *In map case*
Trenton formation 338
Trethewey s. mine.
  See also Meyer vein.
  Bought by Coniagas 82
  Fault 13
  Flow-sheets . . . . *facing* 274, 276
  Iron formation 35
  Silver production 19, 24, 140
  Workings 141
    plan of levels . . . . *In map case*
Trethewey Silver Cobalt Mines, Ltd.
  Capital; dividends 21
Trout lake 195, 198, 199, 208
  See also Tallen s. m.
Trout Lake s. mine 203
Troyes, Sieur de 356 357
Tube mills 253, 254, 260, 263
Tuffs in Gowganda area 336
Tyrrell, J. B. 329, 332
  Notes by, on:—
    origin of ores 330
    veins, S. Lorrain tp. 335
    Wettlaufer m. 227

U

Union Pacific s. mine 171
University s. mine.
  See also La Rose m.
  Development 100, 101
    plan of levels . . . . *In map case*
  Diabase, production below 34, 193
  Section, vertical . . . . *facing* 40
  Silver production 26, 100
Upper contact 7
  See also Geol. of mine workings.
Ural mtns., copper 348

V

Valley fault 13, 14
  Chambers-Ferland m. 162
  Displacement 7
  Nipissing m. 53-56
Van Hise, C. R. 327, 328
  On origin of ores 39
Vein(s) 3
  See also Geol. of mine workings.
  Age and number of productive 333, 335
  Notes by Spurr and Whitman 340, 353
  Relation to faults 16
Vein dikes 3
Vein-filling, character in faults 17
Vermilion iron range 326
Victoria s. vein 105, 106
Victory Silver Mines, Ltd. 184
Vimy Ridge s. vein 178

PAGE

- Violet s. mine.
  - *See also* La Rose m.
  - Diabase sill, section 174
  - Faults 14
  - Greywacké 167
  - Iron formation 125
  - Litigation 122
  - McDonald vein 94
  - Silver from contact 10
    - production 96
  - Workings 96, 97
    - plan of levels *In map case*
- Vivian, H. H., and Co 325

W

- Wad, cobaltiferous 325
- Waldeman s. mine.
  - Production; royalties 22, 27
- Walker, Sir Edmund 350
- Walker, T. L. 36, 344
  - Description by, of Gowganda diabase 351, 352
- Wall rock 351
  - Chemical influence of, on veins 355
- Walsi formation 15
- Watabeag area, rocks 351
- Watash s. m.
  - Diamond drilling, notes and plan 186
- Watson, C. E. 65
- Watson, R. B. 1, 2, 8, 44, 48, 319, 320, 347
  - On amalgamation-cyanidization process 306
  - On sodium sulphide precipitation 293
- Watson silver vein 219-221
- Weatherbee, D'Arcy 66, 70
- Weathering, pre-glacial.
  - *See* Pre-glacial weathering.
- Welch s. mine 28
- West fault 17
- Wettlaufer s. mine.
  - Diabase 199
  - Location, plan showing 203
  - Ore from along contact 231
  - Silver production 19, 192, 224
  - Workings 224-228
    - stopes 194
- Wettlaufer Lorrain Silver Mines, Ltd.
  - Capital and dividends 21, 227, 228
- Wheeler, J. L. 134
- Whitman, Alfred R. 132, 133
  - Notes on origin of ores 343, 346
    - structural geology 340
- Whitman, G. R. 90
- Whitewater series 350
- Wickenburg, Arizona 349
- Williams, M. Y. 338

PAGE

- Wilson, Morley E. 333
- Wood, J. M.
  - Original owner, Keeley m. 204-207, 218
  - Photo 198
- Wood's fault 15, 16, 194, 195, 217
- Wood's vein.
  - Clayey material, analysis 213, 216
  - Cobalt ores, analysis 191
  - Crompton m., notes, photo and production 194, 223
  - Frontier m. 193, 219, 220
  - Keeley m., description and photo 188, 210-15
  - Notes by J. M. Bell 344, 345
  - Occurs in faults 17
  - Stope section on, in Keeley mine *facing* 216
  - Weathering, glacial 193, 353
- World's big silver fields 1
- World's silver production 29
- Worth, S. Harry 156
- Worth's vein.
  - Description and section 152-155
  - Mercer s. mine, prod. 177
- Wright, D. G. H. 351
- Wright, E. V. 358
- Wright, M. P. 158
- Wright, Major Ward 174
- Wright, Sydney B. 320
- Wright galena mine, Que. 321
  - Historical notes 356-358
  - Rocks 325
- Wyandoh s. mine.
  - Royalties; production 22, 27

X

- X fault 13, 17
- Xanthoconite 35
- Xmas s. vein, production 88

Y

- York-Ontario s. mine, production 27
- Young, H. G. 318, 326

Z

- Zacatecas, Mexico, silver prod. 1, 29
- Zinc blende (sphalerite) 35, 246
  - Age of deposition 338
  - Buffalo m. 69
  - Crown Reserve m. 109
  - Frontier m. 352
  - Monte Cristo m. 349
  - Nipissing m. 50, 51, 62
  - O'Brien m. 124, 125
  - Oxford Cobalt and Victory mines 184
- Zinc precipitation 291, 292
- Zoller, F. W. 156

PROVINCE OF ONTARIO
DEPARTMENT OF MINES

HON. H. MILLS, MINISTER OF MINES　　THOS. W. GIBSON, DEPUTY MINISTER

THIRTY-FIRST ANNUAL REPORT

OF THE

ONTARIO DEPARTMENT OF MINES

BEING

VOL. XXXI, PART III, 1922

Blanche River Area

By

A. G. Burrows and P. E. Hopkins

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY OF ONTARIO

TORONTO
Printed by Clarkson W. James, Printer to the King's Most Excellent Majesty
1922

Printed by
THE RYERSON PRESS

CONTENTS

Vol. XXXI, Part III.

PAGE

Introduction 1
Previous work 2
Topography 3
Geology 3
  Keewatin 4
  Pre-Algoman 6
  Algoman 6
  Cobalt Series 6
  Keweenawan 7
  Paleozoic 8
  Pleistocene 9
Gold 10
  Bryce Township 10
  Dack Township 12
  Chamberlain Township 12
Silver 13
  Cane Township 13
  Auld Township 14
  Casey Township 15
  Ingram Township 16
  Bayly Township 16
  Mulligan and Pense Townships 16
Brick Industry 16
Limestone 17
Quartzite 19
Peat Bog 19
Sand and Gravel 19
Water Supply 20
Hydro-Electric Power 20

ILLUSTRATIONS

PAGE

Gold bearing shear zone in andesite, Borgford claim, Bryce township 10
Pit on Borgford claim showing two rusty weathering gold bearing bands 11
Limestone (Lockport) cliffs at Dawson point, Lake Timiskaming 17
Lime kiln on lot 1, concession I, Armstrong township 18
Outcrop of Silurian (Lockport) limestone at Dawson point 19

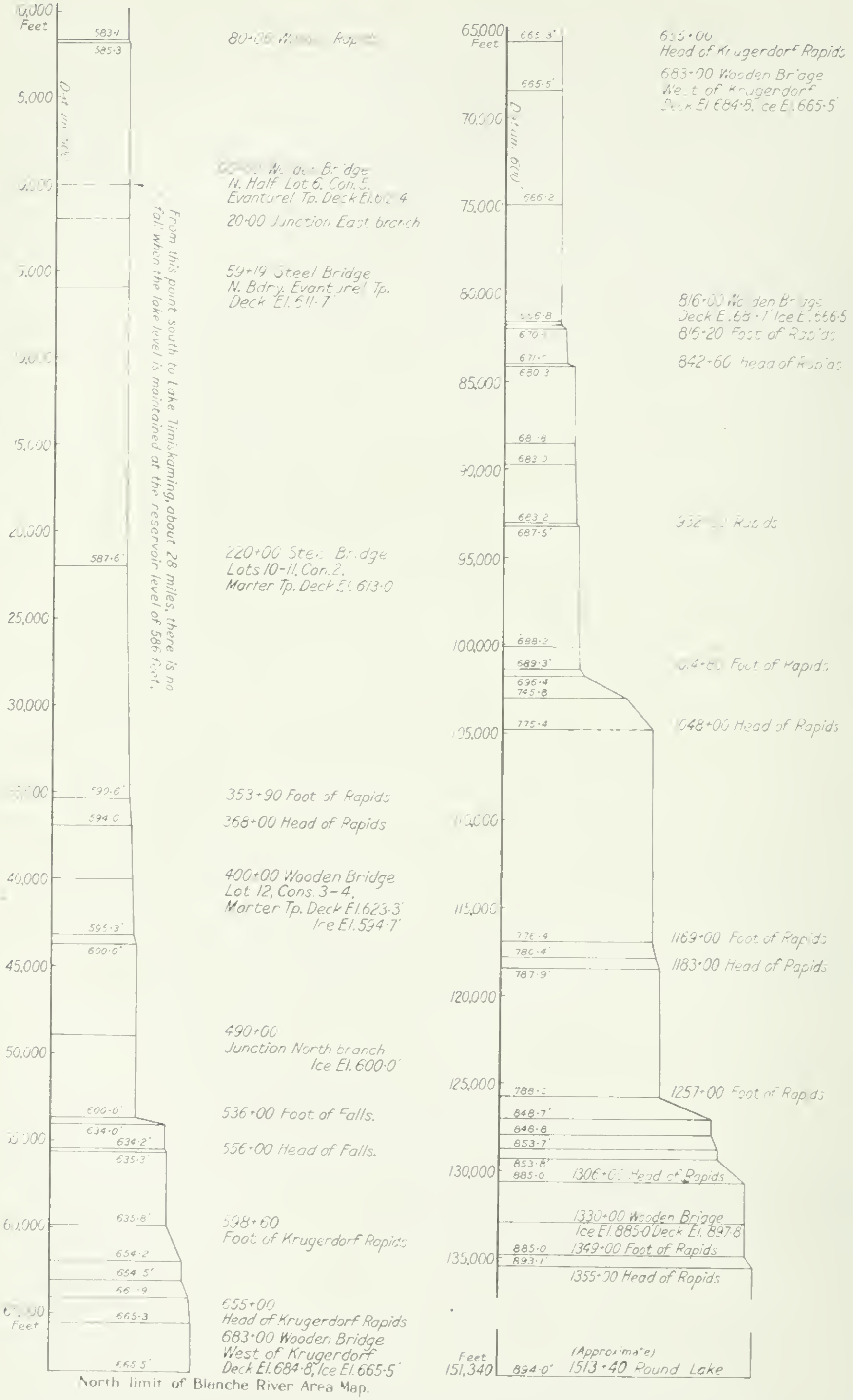
SKETCH MAPS AND DIAGRAMS

PAGE

Profile of a portion (30½ miles) of the Blanche river, scale 2 miles to the inch iv
Key map showing the location of the Blanche River area 1
Cross-section showing the relationship of rocks in Bryce township 10

GEOLOGICALLY COLOURED MAP

No. 31b.—Blanche River Area, District of Timiskaming, scale one mile to the inch
(In pocket on inside of back cover)



Profile of a portion (30½ miles) of the Blanche river, horizontal scale 2 miles (10,560 feet) to 1 inch. Altitudes, determined in March, 1922, by the T. & N. O. Ry., are referred to sea-level.

BLANCHE RIVER AREA

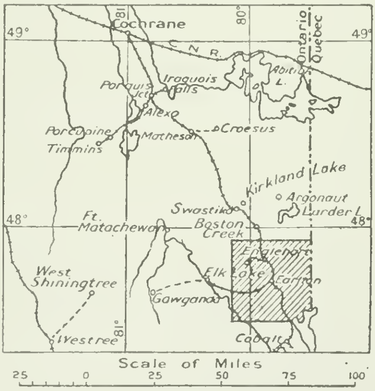
By

A. G. Burrows and P. E. Hopkins

Introduction

This report deals with an area which lies to the north and northwest of Lake Timiskaming, and which is drained largely by the Blanche river and its numerous tributaries. The area includes a block of twenty-five townships, approximately thirty miles square, lying between the Cobalt silver area on the south, and the Boston-Skead gold area on the north. The Ontario-Quebec boundary forms the east limit of the map-sheet; the south boundary is at 47° 30′ north latitude.

Much of the area consists of clay, which is being rapidly cleared for agricultural purposes, the land around Liskeard[1] having been settled prior to 1900. The Temiskaming and Northern Ontario Railway, with branch lines to Elk Lake and Charlton, passes through it. There are good wagon roads and rural telephone lines in many of the townships. Approximately three million ounces of silver have been mined from the Casey-Cobalt mine in Casey township. Rich silver showings have also been found in Cane and Auld townships, and there are indications of silver in the vicinity of Wendigo lake. Prospecting for gold has been carried on in Bryce, Dack, Marter and other townships.



Key map showing the location of the Blanche River Area in reference to the mineral areas of Timiskaming and Cochrane districts.

Accompanying this report is a coloured geological map of the area, on a scale of one mile to the inch, on which are shown the rock outcrops, clay and sand tracts, wagon roads, roads under construction, and many other features.

Most of the field work was done in the summer of 1921, when H. T. Leslie, A. R. Clarke, J. A. Wedge and D. Kearney acted as efficient assistants. The field work was completed in May, 1922, with the assistance of K. B. Heisey and W. Greenwood.

The assays and analyses were made by W. K. McNeill and T. E. Rothwell of the Provincial Assay Office.

---

[1] The name "New Liskeard" is commonly used. In this report the ruling of the Geographic Board of Canada has been observed.

Previous Work

Lake Timiskaming and other geographical features in the area were known to the French as early as 1632. During recent years exploratory trips were made through the area by W. McOuat, W. G. Miller, W. A. Parks and others; however, only a limited portion of the Blanche River sheet has been previously mapped. Considerable geological work has been done in the neighbouring areas of Cobalt, Montreal River and the townships shown on the Boston-Skead map. Following the discoveries of silver ore at Cobalt, a possible silver-producing area was located by prospectors in several townships around Wendigo lake, where the Nipissing diabase was found to outcrop and veins carrying cobalt bloom were found. Portions of the townships of Bayly, Mulligan, Ingram and Pense were geologically mapped by R. E. Hore in 1908.[1] The townships of Casey and Harris were also partially mapped by Mr. Hore in the same year, following a discovery of native silver on the Bushnell property, afterwards known as the Casey-Cobalt mine, in the south part of Casey township.

Native silver was discovered in the townships of Auld and Cane a few years ago, and parts of these townships were mapped in 1920 by A. G. Burrows.

A part of the central portion of the area, extending northwesterly from the north end of Lake Timiskaming, for a distance of twenty-eight miles and for a width of nine miles, is largely covered with Pleistocene deposits of stratified clay,[2] with a few scattered outcrops of Paleozoic rocks. The Paleozoic rocks of Niagara age were recognized as early as 1845, by Sir William Logan around the north end of Lake Timiskaming, and were described by A. E. Barlow in 1897. The Paleozoic rocks near the north end of the lake are shown in the 1910 edition of the map of Cobalt, published by the Ontario Department of Mines.

In 1915, M. Y. Williams recognized the Ordovician (Black River) formation as occurring to the west of Haileybury, fragments of which were found along the shore of the lake by Logan.

In 1916, G. S. Hume[3] mapped the Paleozoic rocks to the northwest of Lake Timiskaming. As the area is largely covered by Pleistocene clay deposits, the records of drill holes in different localities were used by Mr. Hume in determining the distribution of these rocks.

Walter McOuat,[4] one of the earlier explorers, made a micrometer survey of Blanche river from Timiskaming to Round lake in 1872. The main part of the Blanche river flows through the area described in this report. For the first twenty-five miles of its course no rocks were exposed along the shores, after which rocks outcropped infrequently to Round lake. McOuat describes certain rocks as chlorite and hornblende schists and diorite.

W. G. Miller,[5] Provincial Geologist, in 1900, described the geology along the north and Abitibi branches of the Blanche river and Wendigo lake.

In 1904, W. A. Parks[6] made a geological examination along main canoe routes in the area together with some land traverses.

---

[1] Ont. Bur. Min. Reports, Vol. XIX, 1913, Part II, pp. 149-151.

[2] Ibid, Vol. XVIII, 1909, pp. 284-293, by A. P. Coleman.

[3] Paleozoic Rocks of Lake Timiskaming Area, Summary report, Geol. Surv. of Can., 1916, pp. 188-192.

[4] Report of an examination of the country between Lakes Timiskaming and Abitibi, Report of Progress, Geol. Surv. Canada, 1872-73, pp. 112-135.

[5] Lake Timiskaming to the Height of Land, Ont. Bur. Mines Report, Vol. XI, 1902, pp. 214-230.

[6] The Geology of a District from Lake Timiskaming Northward, Summary Report, Geol. Sur. Canada, 1904, pp. 198-225.

Topography

A marked characteristic of the region is the flat plain extending northwesterly from Lake Timiskaming. This is composed of Pleistocene clays and flat-lying Paleozoic rocks, and has an elevation of 630 to 820 feet. The clay plain has been deeply intersected by V-shaped valleys formed by the Wabi and Blanche rivers and their many tributaries, which empty into Lake Timiskaming. The Blanche river at Englehart has cut at least 100 feet into the plain. The streams have a turbid appearance due to finely-suspended clay particles. The Montreal river cuts across the southwest corner of the map-sheet. Long Lake, near Charlton, is the largest lake in the area. An arm of the clay plain extends southwesterly from Earlton, along which runs a branch line of the railway. This portion in part of Kerns, Henwood and Cane townships, consists of flat-lying pre-Cambrian quartzite. Around these flat areas, the country is hilly, due to the uneven erosion of the pre-Cambrian rocks, and has the general appearance of the pre-Cambrian topography throughout most of northern Ontario.

A plain of good agricultural land, from 200 to 250 feet higher than the Englehart-Liskeard plain, occurs in the vicinity of Charlton, in parts of Dack, Robillard, Beauchamp, Savard and Chamberlain townships. Hills of Keewatin lava and agglomerate rise 200 to 300 feet above this plain, near the boundary between Dack and Beauchamp townships. Some very marked ridges and hills occur in other portions of the area. High ridges of Nipissing diabase form striking features in Auld and Cane townships. The northeast part of the area, in the townships around Wendigo lake, is particularly rugged, some of the ridges being 300 feet above the lake. There are also some pronounced conical hills of Keewatin diabase in Brethour township. In the township of Beauchamp the chief features are the high morainic hills and ridges of sand and gravel which form some of the highest points in the area. Other sand areas accur in northeast Marter and in southwest Hudson township. A prominent sand and boulder ridge extends in a northwest-southeast direction across Armstrong, Hilliard and Harley townships.

Geology

There is a wide range of rocks in the area, including many members of the pre-Cambrian, varying in age from much altered lavas of the Keewatin to well-preserved Keweenawan diabase, and in addition areas of fossiliferous dolomite of early Paleozoic age. It is unusual to see formations that are younger than the pre-Cambrian represented on maps of portions of northern Ontario. The Keewatin, Algoman, Animikean, Keweenawan and Silurian are all prominently shown on the accompanying map. The pre-Cambrian rocks are similar to those described in reports on surrounding areas.

The geological divisions are shown in the table of formations which follows, the oldest being placed at the bottom.

TABLE OF FORMATIONS

PLEISTOCENE
GLACIAL AND RECENT—
    Peat bog.
    Sand, gravel, sandy loam and boulders.
    Stratified clay, boulder clay, clay loam, sandy clay.
PALEOZOIC
SILURIAN—
    Lockport dolomite and sandstone.
    Cataract limestone and impure shales.
ORDOVICIAN—
    Trenton limestone.

Unconformity

PRE-CAMBRIAN

KEWEENAWAN—

Diabase dikes and sills, granophyre.

Intrusive Contact

ANIMIKEAN (COBALT SERIES)—

Quartzite.

Conglomerate, arkose, greywacké and slate.

Unconformity

LAURENTIAN OR ALGOMAN—

Quartz-porphyry, aplite and felsite dikes.

Hornblende-biotite granite, syenite and gneiss.

Intrusive Contact

PRE-ALGOMAN (?)—

Diabase.

Intrusive Contact

KEEWATIN—

Rhyolite, andesite and dacite.

Amygdaloidal and ellipsoidal basalt, agglomerate, diabase, hornblende and chlorite schist.

Mica schist.

Keewatin

The Keewatin occurs prominently in the west part of the area, namely, in the townships of Robillard, Bryce, Dack and Beauchamp. Similar rocks occur in the townships of Marter and Bayly, while a few scattered outcrops of Keewatin are found near the Ontario-Quebec boundary.

Basalt and Andesite.—The Keewatin consists principally of altered basic lavas which were originally basalt. These are quite dark-coloured, and frequently show the pillow structure so characteristic of basic lava flows of this age. The lavas in Robillard township are chiefly dark-coloured with pillow structures and frequent amygdules, and in places are altered to hornblende and chlorite schists. The basic lavas extend southerly into the north part of Bryce township, while farther south they become lighter-coloured, approaching andesite in composition.

With the andesite there is a light, greenish-grey rock which has the composition of dacite, or possibly rhyolite. A great part of Bryce is covered by the lighter-coloured andesitic and dacitic rocks. The pillow structure was observed in andesite on lot 2 along the line between concessions III. and IV. The rock has a slightly porphyritic texture, showing phenocrysts of plagioclase and smaller crystals of biotite altered to chlorite, while a second generation of plagioclase is shown in the groundmass. In places the andesite has an amygdaloidal structure.

The dacite shows phenocrysts of quartz as well as plagioclase and is lighter-coloured than the andesite. Much of the rock has an ash grey colour on the weathered surface. In lots 10 and 11, concession IV., Bryce township, there are grey feldspar porphyry masses which may be differentiation phases from the andesite magma.

The lavas are altered in places to schist with a strike approximately N 70° W, and dip 60 deg. to 80 deg. north.

With the light-coloured lavas there are bands of agglomerate breccia or tuff-like deposits of material similar to the lavas, which make up a great part of the light coloured rock. These occur in lots 9 and 10, concessions II and III and in lot 5, concession VI, Bryce, and on the boundary between Beauchamp and Dack townships. Ash rocks are likewise associated with the more basic lavas on the boundary line between Dack and Chamberlain townships.

The composition of the andesite and dacite is shown in the following tables:

(1) Lot 11, line between concessions III and IV, Bryce.

(2) Lot 10, concession IV, Bryce; Analysts, W. K. McNeill and T. E. Rothwell.

	(1) Andesite per cent.	(2) Dacite per cent.
Silica	61.56	70.68
Alumina	17.96	15.79
Ferrous Oxide	4.95	4.75
Ferric Oxide	1.01	1.17
Lime	3.86	1.17
Magnesia	2.58	0.94
Potash	0.42	2.01
Soda	4.16	3.05
Carbon Dioxide	0.94	1.02
Water	2.82	2.05

Some shear zones carrying values in gold occur in the light-coloured volcanics in Bryce township.

The andesite which covers nearly all the southwest part of Skead township extends southerly into Bayly, most of the northwest part of the latter township being covered by andesite, with the exception of some diabase dikes and a little conglomerate near Wendigo lake. With the andesite is a breccia which is made up of fragments of the andesite. This type of rock occurs in lot 3 concession IV, Bayly township. No gold deposits were seen in Bayly township, however the andesite of Skead township is known to contain gold-bearing veins.[1]

Mica Schist.—There are several outcrops of mica schist in the eastern part of the area. They occur along the boundary line between Ontario and Quebec, about two miles north of the southeast corner of Mulligan township. Mica schist occupies a large part of the southeast portion of Pense township and also a part of Brethour. Similar rock occurs in small patches in Casey township.

The rock is a fine-grained biotite schist, containing numerous quartz grains. It is grey to black in colour, depending on the proportion of biotite, and often has a rusty surface due to the oxidation of disseminated iron pyrites. In places there is a definite banding or stratification, indicating an origin from a quartzose sediment. Irregular lenses of quartz occur in the schist in the direction of schistosity which is generally east and west. The rocks usually dip to the north at about 80 deg. A few narrow dikes of diabase intrude the schist.

From the description given by Morley E. Wilson [2] of the Pontiac series which he found to occur in a large area in Quebec to the east of Larder lake, it is evident that the rock above described is similar to the Pontiac schist. Wilson did not find any relationship between the mica schist and the Keewatin greenstones, and consequently placed the schist in a separate series. Some of the greenstone in Pense township does not appear so highly metamorphosed as the mica schist, but the rocks were not observed in contact. It has been thought advisable to group the mica schist with the Keewatin rocks on the accompanying map. In the southeast part of Pense township the mica schist has been intruded by coarse hornblende syenite. The mica schists resemble the Couchiching of western Ontario.

---

[1] Boston-Skead Gold Area by A. G. Burrows and P. E. Hopkins, Ont. Dept. of Mines Report, Vol. XXX, 1921, Pt. 6.

[2] Larder Lake District. Geo. Sur. Can. Memoir, 17E, p. 27.

Pre-Algoman ?

Cutting the andesite to the north of Wendigo lake on lots 7 and 8, concession III, IV, and V, Bayly township, is a massive altered diabase which may be pre-Algoman in age. The rock is clearly intruded by a Keweenawan diabase dike, but its relationship with the other rocks is not known.

Algoman

Pink and grey biotite granites occur in several parts of the area. The largest volume is that which covers Savard and parts of Bryce, Robillard and Chamberlain townships. The granite is part of a larger area that extends northerly in Pacaud and Marquis townships, and westerly towards Elk lake. The batholith of biotite granite is generally massive in structure, but near the contact with older rocks it may be gneissoid. It is pink to grey in colour, and frequently shows spots of quartz, stained a bright red, greatly resembling garnet in appearance. The chief constituents are quartz, orthoclase, plagioclase, biotite and augite, with small amounts of apatite and rutile.

A smaller mass of pink biotite granite outcrops in the east part of Mulligan township, extending easterly into Quebec.

A fine-grained white-weathering granite, or aplite, intrudes mica schist on lot 9, concession III, Pense township. In lot 11, concesion I of the same township the mica schist is intruded by a coarse red hornblende syenite.

Grey granite and gneiss occur on lots 10 and 11, concession II, Cane township. The area is small and has been exposed by erosion of overlying Cobalt series quartzite, and Nipissing diabase, which are the other rocks in the vicinity.

A few narrow quartz and feldspar-porphyry dikes are shown on portions of the accompanying map. Several narrow dikes occur in Keewatin schist between Charlton and Englehart near the periphery of a granite batholith. The porphyry occurs in larger volume in lots 10 and 11, concession III, Bryce township. At the latter locality the grey feldspar-porphyry may be a differentiation phase of the adjoining andesite; the porphyry also contains narrow gold-bearing veins. Somewhat similar porphyry occurs with the andesite in Bayly township. A quartz-porphyry dike occurs on the west boundary of Bryce township.

Cobalt Series

The series of sedimentary rocks occurs prominently in the east and southwest parts of the area. Around Wendigo lake, there are ridges of greywacké, quartzite and conglomerate, with which is associated the Nipissing diabase forming some of the highest points in the area. The sediments in the southwest part are largely reddish quartzite and arkose, which form the latest rocks of the Cobalt series. The quartzite is in comparatively low ridges outcropping through the clay and sand in the townships of Cane, Henwood, Auld and Lundy. In the township of Bryce there are scattered outcrops of conglomerate and reddish slate like greywacké which overlie the Keewatin schists and are intruded by the Nipissing diabase. The latter sediments are thin remnants along the margin of the large area of Cobalt series lying to the south.

Where exposed, the series is very little disturbed, having the nearly horizontal attitude characteristic of most of the Cobalt series which has been mapped over several hundred square miles of country to the south, southwest and west. To the west of Wendigo lake some of the boulders in the conglomerate are ten inches across.

A number of contacts with the older rocks were observed, some of the best being in Bryce township where numerous patches of conglomerate overlie the basalt, andesite and rhyolite, the old surface of the Keewatin on which the sediments were laid down, being much like that of to-day. Some of these small patches of conglomerate were seen in lot 5, concession VI, Bryce township, four miles from the main mass of sediments to the south. In the northeast corner of Mulligan township the conglomerate contains numerous grey, medium-grained biotite granite pebbles derived from the underlying granite in the immediate vicinity.

The order of deposition of the members of the Cobalt series in Bryce and Cane townships from the oldest to the youngest is as follows: conglomerate, banded reddish slate-like greywacké with thin beds of conglomerate, quartzite and arkose.

Keweenawan

The Keweenawan diabase, which has such a wide distribution in northern Ontario and which is known to be associated with the silver deposits of Cobalt and elsewhere, occurs in various parts of this area, particularly in the northeast and southwest. The country round Wendigo lake is very rocky and prominent ridges of diabase are found in the townships of Bayly, Mulligan, Pense and Ingram in the vicinity of the lake. Scattered ridges and hills of diabase outcrop through the heavy mantle of clay or sand southerly to Casey and Harris townships. In the southwest part there are ridges of diabase in Auld, Cane, Bryce and Lundy townships, while near Cobalt, in Hudson and Dymond townships, the diabase is also found. A number of relationships were observed in the field which confirmed the previous information regarding the sill form of the diabase. The best contacts were found in the township of Bryce, where both footwall and hanging-wall conditions occur, and a small area of diabase was seen from which the overlying rocks had been eroded, exposing the top of the sill. These features were observed on lots 8 and 9, concession II, Bryce township. The relationships between the diabase sill and the older rocks in the locality are shown on the accompanying cross-section. Similar structures occur in Auld and Cane townships, and are referred to in a previous report. R. E. Hore refers to the sill-like character of the diabase in his description of the occurrence near Wendigo lake. He states: "At the foot of cliffs of diabase, the igneous rock is seen to overlie horizontally bedded, slaty greywacké. At the west end of Lake Wendigo the slate dips slightly to the south under diabase. The cooling of the igneous sheet has produced vertical cylindrical columns. These are often well exposed in the ridge north of Ingram township, where columns twenty to thirty feet in diameter form the vertical cliffs, while wide cracks mark out the continuation of the column boundary."[1] The top of the diabase sill may also be seen in lot

---

[1] Ont. Bur. Min. Report, Vol. XIX, 1913, Part II. "Area South of Lake Wendigo."

10, concession III, Kerns township, and the bottom of the sill in lot 2, concession I and lot 1, concession IV of Hudson township.

Normally the diabase has the dark greyish to greenish colour characteristic of the major part of the sill in northern Ontario which has been described by Knight and other writers in earlier reports.

The typical diabase contains dark-coloured plagioclase, brown augite, a little biotite, and usually a little quartz intergrown with feldspar, also magnetite or ilmenite as accessory minerals.

A red rock, or granophyre, is found in minor quantity, particularly in the southwest part of Cane township, and is probably associated with the diabase as at Gowganda. The neighbouring rock in this locality is a feldspathic quartzite, and it is likely that some of the red rock has been formed by assimilation of the quartzite by the diabase, since it is difficult to distinguish the two rocks when found in the same outcrop. Granophyre also occurs in lot 9, concession III, Kerns township.

In places the diabase occurs as dikes. At Kenabeek station the contact between the diabase and quartzite appears to be vertical.

Considerable cobalt bloom occurs in the diabase in parts of Pense, Mulligan and Ingram townships. Promising silver-bearing veins occur in the upper part of the diabase sill in Cane and Auld townships. Much silver has been produced at the Casey-Cobalt mine in Casey township, the ore coming from sediments which were probably overlain by diabase.

Paleozoic

The latest report on the Paleozoic rocks of Timiskaming is by G. S. Hume[1] who mapped the formations in 1916. A large area of Ordovician and Silurian has been preserved by faulting. The strong NW-SE fault to the northwest of New Liskeard was first recognized by W. G. Miller.[2] The fault scarp, which is the continuation of the west shore of Lake Timiskaming, has been traced by Hume for 12 miles to the north part of Kerns township where the ridge flattens.

Hume classifies the Paleozoic rocks into an upper division, Silurian, consisting of Lockport and Cataract formations, and a lower division, Ordovician, consisting of Black River-Trenton. In 1915 M. Y. Williams[3] recognized the limestone on the ridge to the west of Haileybury as Ordovician, similar rock occurring to the west of Liskeard. The Ordovician formations here are on the west or upthrow side of the fault. Most of the exposures of dolomite to the east of the fault are referred by Hume to the Lockport, while the Cataract is exposed below the Lockport at Dawson point, and outcrops at the falls two miles south of Englehart. Hume also recognizes a thin band of Cataract extending northwesterly from the east side of Dawson point to Englehart. To the east of this, the same author has mapped a band of Ordovician extending to the pre-Cambrian rocks near the Blanche river.

The limestone of the area has been used for building purposes and for producing lime: also in connection with the paper sulphite plant at Iroquois Falls.

---

[1] Paleozoic Rocks of Lake Timiskaming Area, Summary Report, G.S.C., 1916, pp. 188-192, and accompanying map.

[2] Ont. Bur. Min. Reports, Vol. XIX, Part II, p. 120.

[3] The Ordovician Rocks of Lake Timiskaming. Museum Bulletin No. 17., Geo. Sur. Can.

Pleistocene

The greater part of the area is covered with Glacial and Recent deposits of unconsolidated material, stratified clay, sand, gravel, etc. The stratified clay is the most abundant of the superficial deposits, covering most of the townships extending northerly from Liskeard to beyond Englehart. The clay deposits are in a low area, which rises gradually to the north. The plain-like region broadens near Earlton, a narrow belt of clay extending southwesterly into Henwood and Cane townships, while easterly beyond the Blanche river in parts of Ingram, Hilliard and Brethour townships the clay contains much sand. To the west of Englehart there is a ridge of Keewatin greenstone and granite for a few miles, beyond which the clay continues over several townships around Charlton. Here, the underlying rocks are pre-Cambrian, and there are scattered hillocks and ridges of rock protruding from the soil. This clay area is 200 to 250 feet higher than the plain between Englehart and Earlton. The deposits of clay become scattered toward the north, consequently the rocky portions are more numerous and the country not so suitable for agriculture.

The presence of the large tillable clay area made possible the opening of a number of townships for settlement in past years, and the agricultural land available has been taken up by settlers. Many parts of the area have had well established communities for several years, the first settlements having been made near Liskeard over thirty years ago.

The elevation of the clay plain varies from 642 feet at Liskeard to 816 feet at Earlton, while at Englehart, farther north, it is only 677 feet.

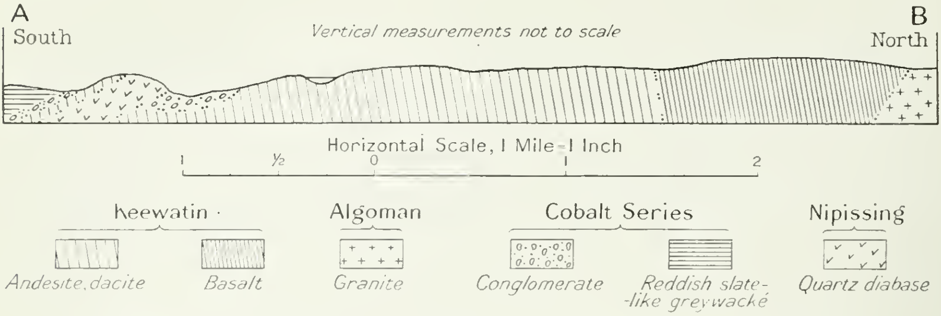
The clay deposits comprise alternating layers of dark and light-coloured materials, one-half an inch or over in thickness, which were formed in fairly deep waters. The deposits are in places from 100 to 200 feet in thickness. Red brick has been made from the clays at Liskeard. The clay in many parts of the area is overlain by sand, silt and gravel. Much of the eastern portion of Marter township is sand, which can be traced to the north for twenty-five miles. In the northeast part of the township the sand rises to a height of 100 feet, while farther south in the same township it gives way to a sandy loam which is covered in places by a thin covering of clay. Sand can be seen lying on stratified clay in a section of the river bank in lot 3, concession III, Marter township.

High morainic ridges occur in the west part of Beauchamp and the east part of Bryce in concessions II and III. These ridges are 100 to 150 feet above the plain. Several depressions represent old kettle lakes, many of which are now dry. To the south of the morainic ridges there is a broad sand plain, stretching southerly into the north parts of Cane and Henwood townships, which is possibly an outwash plain from a glacier.

A narrow sand-gravel-boulder ridge extends in a southeasterly direction for nine miles from lot 3, concession IV, Armstrong township to the southeast corner of Harley township. Silurian limestone outcrops at intervals along the ridge.

A glacial morainic deposit extends east of the Blanche river near Judge post-office in Casey township.

Where the rocks are exposed one often sees the glacial grooves and scratches, which strike from S. 30° E. to S. 50° E. astronomic.



Cross-Section on line A B (*See* map No. 31b) showing the relationship of rocks in Bryce township.

Gold

Bryce Township

Gold has been discovered on several lots in the township of Bryce. Since the township has been almost completely burned over. the rocky portions are well exposed for prospecting

Thelma.—Some years ago a shaft was sunk on the south half of lot 8, concession II by the Thelma Mining Company. The rock is schistose Keewatin, which is probably an altered andesite. This is cut by a quartz vein which, at the shaft,

Gold bearing shear zone, about 15 inches wide, in white weathering andesite. Borgford claim, Bryce township.

is 3 to 6 inches in width. It strikes N. 53° W. and has been traced about 200 feet with varying widths, showing small stringers running from the vein. The shaft could not be examined, but some of the vein material on the dump carries iron pyrites, copper pyrites, pyrrhotite and specularite, a sample of which gave no results in gold. It is reported, however, that some gold was obtained in samples from the vein. The Keewatin is here underlain by the Nipissing diabase sill.

Pit on the Borgford claim, north ½ lot 9, concession II, Bryce township, showing two rusty weathering gold bearing bands, each one foot in width.

Borgford.—During the summer of 1920 George Borgford of Elk Lake discovered some gold-bearing shear zones in the north parts of lots 9 and 10, concession II, Bryce township. Following this discovery a number of claims were staked in the vicinity. The rocks which carry the gold deposits are andesite, dacite and agglomerate, which are light greenish-grey in colour. These rocks are quite schistose in places, particularly in the vicinity of the veins. The ellipsoidal and amygdaloidal structure is not common, although numerous bomb-like inclusions were noted in the agglomerate. In some places the rock is quite porphyritic. The shear zones are recognized by the abundance of iron pyrites which is oxidized on the surface, staining the light-coloured rock a rusty brown. The rusty bands strike 20 degrees north of west, dip 80 degrees northerly, and are traceable at least 400 ft. The rusty streaks average about one foot in width, and one pit shows two of these three feet apart. They contain schist impregnated with iron pyrites, copper pyrites and quartz, together with some calcite, feldspar, pyrrhotite and zinc blende. A sample from a 12-foot pit near the east boundary gave $5.60 in gold per ton over a width of ten inches. Other samples from the same pit gave 80 cents and $2.00 per ton over narrow widths. Samples of the rock from the pit and adjacent to the rusty streaks gave no gold on assay.

Two samples from a pit 4½ chains southeast on lot 9, concession II gave 40 cents and 80 cents over widths of 12 inches, The three feet of rock between gave an assay of $1.20 per ton.

Quesnell.—Some years ago a 20-foot pit was sunk on an 18-inch white quartz vein in andesite in the southwest part of lot 10, concession II, Bryce township. The vein strikes approximately east and west and is traceable for 400 feet. Four men were trenching the vein in May, 1922. The quartz in places carries some iron and copper pyrites and the wall rock is scistose. Mr. Quesnell stated that a vein one quarter of a mile west gave encouraging values on assay.

S. W. ¼, S. ½, Lot 8, Con. III.—Some shallow pits have been sunk on bands of pyritous schist on this claim. A selected sample of the schist zone gave an assay of $2.40 per ton.

Lot 6, Con. VI.—A shaft was sunk in the basalt on some stringers of quartz carrying a little iron pyrites and pyrrhotite. No gold was shown on assay of several mineralized pieces of quartz from the dump.

Dack Township

A 100-foot inclined shaft has been sunk at a 30-foot falls on the Blanche river on the *Parker* claim in lot 7, concession IV. The shaft is sunk in a pronounced fault which strikes N. 30° E and dips 80° to the N. 60° W, the rocks being Keewatin serpentinous diabase and talc schist. Fragments of quartz, calcite, pyrite and chalcopyrite taken from the dump showed an absence of gold on analysis.

A narrow band of highly altered Keewatin schist occurs on the southeasterly periphery of a granite batholith extending in a northeasterly direction from the town of Charlton to lot 4, concession I, Chamberlain township. These lava schists, rusty carbonates and tuffs are intruded by a few small dikes of porphyry and lamprophyre, and contain occasional quartz veins. A shallow pit has been sunk in this zone on a porphyry dike with quartz veinlets near the hydro-electric power station at Charlton. A pit has also been sunk on a narrow quartz vein carrying iron pyrites on the *Scott* location, the south half of lot 6, concession V, Dack township. Considerable trenching has been done on the *McPherson* farms north parts of lots 4 and 5, concession VI, Dack township, exposing a quartz vein two to three feet in width and over a quarter of a mile in length. Two channel samples of quartz carrying iron pyrites, talc and dolomite from the vein gave on assay 40 cents and 80 cents in gold per ton.

Chamberlain Township

The McPherson vein extends northeasterly to the *Grant* location, lot 4, concession I, Chamberlain township. Several quartz veins can be seen in the railway rocks cuts on this lot: however, two samples, well mineralized with pyrite, showed no gold on assay.

Silver

Native silver, smaltite and niccolite and other related minerals have been found in several townships shown on the accompanying map. Silver ore has been shipped from the townships of Casey and Cane.

There are a number of veins of calcite and dikes of aplite in the townships of Auld and Cane that are silver-bearing. They occur toward the hanging-wall side, or upper part, of the diabase sill. The main outcrop of diabase is a long narrow section of a sill extending in a general north and south direction. The veins of calcite and dikes of aplite are approximately at right angles to the contact of the sill with the overlying quartzite, consequently the strike approaches east and west. A number of properties have been located on the diabase ridge, and the exploration of those along the easterly side has shown silver-bearing veins of promise.

Generally where an aplite dike is mineralized, it is accompanied by calcite and quartz veinlets, either irregularly in the dike or parallel to it. Veins in which aplite, quartz and calcite occur are more numerous than the ordinary silver-bearing calcite veins. The silver-bearing aplite dikes vary in width from an inch to 18 inches. The aplite is a differentiation from the diabase magma, sometimes occurring in dikes with well-defined walls. Again, the aplite may grade into the normal dark diabase and still have a dike-like structure, suggesting a segregation from the diabase magma in the process of cooling with consequent shrinkage, the more acid portion of the aplite being near the centre of the dike.

The quartz in the veins is later than the aplite, and the calcite the latest gangue mineral. Frequently there is a narrow band of quartz between the diabase, or aplite, and the calcite.

The smaltite usually accompanies the calcite, and native silver may occur as masses in the smaltite and calcite, or as sheets and scales in the quartz, aplite and diabase. Where veins of calcite occur in diabase or aplite, one portion may be replaced over its width with massive smaltite and silver, and thus show bunches or small shoots of high-grade along the vein, with adjacent parts containing little or no smaltite or silver.

Cane Township

Cane.—The Cane Silver Mines comprise three mining claims, M. R. 5227, 5251, 5276, in lot 2 in the second concession of Cane township. They are situated along the narrow ridge of diabase that extends from Auld to Cane.

A number of silver-bearing veins occur along the easterly side of the diabase ridge in proximity to the overlying quartzite, consequently they are in the upper part of the diabase sill. They are approximately at right angles to the contact, varying in strike from N. 70 deg. E. to S. 70 deg. E. Eight veins have been located and work was being done on three of them in the fall of 1920. Open cuts were made on veins Nos. 1, 2 and 8, and ore has been bagged from each of these. No. 1 was traced 175 feet, with strike N. 70 deg. E. and dip 80 deg. N., extending westward across the boundary to the next claim. This vein is aplitic in character, showing lenses of calcite, smaltite, niccolite and silver and some bismuth, varying in width up to four inches. There are also branching veins, in one place three in a width of four feet. There is some leaf silver as well in the diabase along the veins. One lens of high-grade ore that was mined was about three feet long, carrying massive smaltite studded with native silver. A sample of high-grade ore has the following partial composition: Co.—19.29; Ni.—3.67; As.—46.44 per cent.

An open cut was made on No. 2 vein, which contains two leads about two feet apart. Aplite is also the chief gangue of these veins, one showing a width of two or three inches, with streaks of high-grade silver ore about one-quarter to one-half inch thick, and forming a rib-like structure in the aplite. At times the high-grade ore runs diagonally across aplite. These high-grade streaks carry silver, smaltite and calcite. Some leaf silver is also found in the diabase near the veins.

No. 8 vein, on the northerly claim of the group, is also of aplitic dike character with an average width, where exposed by trenching, of 14 inches. One section of the dike for 20 feet shows an abundance of cobalt bloom on the surface. An open cut was made along this section, revealing lenses and impregnations of smaltite carrying native silver. The silver-bearing smaltite occurs irregularly, sometimes along the walls of the dike, sometimes running diagonally across the dike, and again as rounded nodular-like masses in the aplite. The aplite where it contains smaltite and silver is impregnated with calcite. A shaft was sunk on this vein, using hand steel, to a depth of 40 feet, the vein maintaining its width with ore similar to that found on the surface. Work was stopped in December. It is expected that a compressor plant will be installed at a later date when mining will be resumed. Previous to October 1, 1920, 100 sacks of ore weighing 3½ tons and assaying 402 ounces of silver per ton, were shipped from open cuts to the Cobalt Reduction Company. One hundred sacks in addition were taken from the open cuts and shaft before work ceased for the winter. J. J. Byrne is manager of the property.

Shepp.—The two principal claims of the group are M. R. 5279 and M. R. 5286, lying just northeast of the Cane Silver Mines. An aplite dike 8 inches wide and dipping 80 deg. N.E. crosses the line between the two claims; two shafts have been sunk to moderate depths and some trenching done. The southerly shaft was sunk at the junction of two aplite dikes 6 inches and 8 inches in width. The material on the dump shows some massive smaltite, partly altered to cobalt bloom, together with a little native silver. The exposure here somewhat resembles that at No. 8 vein at the Cane mine. At the time of examination the shafts were filled with water, but work was to be resumed in the spring of 1922, the intention being to sink to a depth of 100 feet and to cross-cut to the vein. The owning company is Ontario Solid Silver Mines, Limited.

Auld Township

Triangle.—The Triangle Silver Mines, situated in Auld township, consists of 1,000 acres, being part of lots 2 and 3 in the fifth and sixth concessions. Silver was discovered on the group in 1912, and this discovery is described by C. W. Knight[1] as follows:

> On the Hitchcock location, south half of lot 3, con. VI, there are a number of narrow east and west veins, in some of which native silver with some smaltite and bloom have been found. The wall rock of the veins is usually aplitic. On the westerly side of the easterly diabase ridge native silver occurs at two points in fairly coarse dendritic form. At the northerly exposure there is coarse-grained reddish aplite which is heavily stained with bloom. The aplite has more the character of a differentiation of the diabase than a clearly defined dike. At the other exposure where silver was seen, there is a grey aplite along one perpendicular surface of which there is native silver in dentritic form.

---

[1] Ont. Bur. Min., Vol. XIX, 1913, Part 2, p. 163.

Veins were later discovered on lot 2 lying to the east and near the contact with the quartzite. The group of claims was operated first as the Kenabeek Silver Mines, later re-organized as the Triangle Silver Mines. On lot 2, a tunnel has been driven westward on a fracture on the east side of a high diabase ridge. The principal work, however, has been on a series of veins, the principal one of which strikes N. 66 deg. E. and dips 80 deg. S. A shaft has been sunk to the 132-foot level, on the dip of the vein, and to the 182-foot level at a flatter angle. Drifting and cross-cutting have been done on the two levels, most of the work being on the upper level. A faulted zone, 10 feet to 12 feet in width and dipping flatly southward, was encountered at the first level.

The calcite veins on which underground work was done carry segregations of native silver, smaltite and niccolite. The veins vary from an inch to six inches in width, while some heavy sheet silver is occasionally encountered in the wall rock. A small quantity of ore has been raised from the mine, but no shipments have been made. W. R. Hitchcock is managing director and W. H. Jeffrey mine manager.

Bradley-Donaldson.—The Bradley-Donaldson property includes the south half of lot 5, Con. IV., Auld. It is situated on the west side of Lepha lake, along the westerly shore of which is a high diabase ridge sloping steeply to the lake. No work has been done for several years, and the camp buildings are dismantled. A tunnel was run westward into the ridge on a calcite vein near the south boundary of the property, and it is stated that some native silver was obtained from the workings now filled with water. Fragments from the dump show a banded structure in the vein, which is composed chiefly of grey calcite with narrow ribbons of quartz. The structure indicates a replacement type of vein along a fracture in the diabase. In this locality the diabase dips steeply beneath the quartzite, and the workings are near the upper contact.

Casey Township

Casey-Cobalt Mine.—The property is situated on the southeast quarter of the south half of lot 5, concession I, Casey township, about 10 miles northeast of the town of Liskeard. The mine was operated from 1908 to 1919, during which time it produced 2,946,512 oz. silver and paid $203,249.33 in dividends. The property has been described in the report on "The Cobalt-Nickel-Arsenides and Silver Deposits of Temiskaming."[1] The producing veins were in rocks of the Cobalt series. C. W. Knight states that the shaft passed through 240 feet of conglomerate greywacké and greywacké slate, after which it met with an old complex consisting largely of lamprophyre and fine-grained greenstone. About a quarter of a mile northerly from the shaft the Nipissing diabase was seen resting on the sediments of the Cobalt series and dipping apparently to the east. It is probable that the diabase sill originally covered all the rocks on the present hill, it having now been largely eroded. Conditions are therefore similar to those at Cobalt where the greater part of the silver mined has been from veins in the Cobalt series beneath the Nipissing diabase sill.

Casey Mountain.—This property comprises portions of lots 6 in the second and third concessions of Casey township. On the location is a large diabase outcrop surrounded for some distance by clay and sand. According to the general manager, R. G. Williamson. No. 1 shaft is 415 feet deep with 90 feet of drifting at the 50-ft. level, a short drift at the 100-ft. level, a cross-cut at the 325-ft. level and 116 feet of cross-cutting at the lowest level. Some diamond drilling has also been done on the lower levels. The No. 1 shaft showed 140 feet of conglomerate between the diabase capping and the underlying Keewatin. No. 2 shaft to the north is 245 feet deep. Seventeen men were employed at the property in October, 1921.

---

[1] Ont. Bur. Min. Reports, Vol. XIX, Part 2, p. 148.

Ingram Township

The township of Ingram is for the greater part covered with drift deposits, most of the township being suitable for agricultural purposes. There is a small amount of diabase exposed in the northern part and, during past years, some prospecting was done in the diabase near Mallard lake. An old pit in the south half of lot 10, concession VI reveals a narrow calcite-quartz vein containing a little cobalt bloom. On the south half of lot 11, concession VI a pit was sunk on a three-inch calcite-quartz vein containing some small masses of galena, a sample of which contained 4 oz. silver per ton.

Bayly Township

No work was being done in this township while the geological examination was being made. During past years, however, several pits were sunk in the search for silver. On claim J.S. 19, which is in the south part of the south half of lot 7, concession III, there are three pits in diabase showing some small gash veins. Some of the material on the dump of one pit carries a little galena, zinc blende, and garnet in calcite-quartz veinlets. The veinlets indicate no value where exposed.

On the northwest quarter of the north half of lot 5, concession III, there is a pit on an aplite dike 2 to 3 inches in width which runs N 17° W in a wide diabase dike. The aplite carries copper pyrites, but no cobalt bloom, often an accompaniment of aplite, was observed along the dike.

Mulligan and Pense Townships

In 1906, R. E. Hore examined an area south of Wendigo lake, including parts of the townships of Ingram, Pense, Bayly, and Mulligan, where several small quartz veins carrying cobalt bloom had been found in Nipissing diabase. No native silver or argentite was seen, but Mr. Hore noted small quantities of sphalerite, galena and smaltite in some of the veins.[1] In 1918 many of these claims showing cobalt bloom were re-staked, but no further development work was done.

Brick Industry

All through the clay belt, the Pleistocene clay is remarkable for its even stratification. The bands are alternately of light and dark colour, the light layers containing more lime. Attempts have been made to use the clay for the manufacture of bricks at Liskeard and Haileybury. The clay in the upper 6 feet contains many limy nodules, apparently the result of percolating waters, and where these are not removed from the brick clay, white spots result which spoil the appearance of the bricks and later cause them to burst, owing to the slaking of the lime of the nodules. Even when the clay is obtained from a deep pit where no nodules are present, it is found that the bricks are of an inferior quality, owing to the large content of lime. To overcome the difficulty, sand was added, but owing to its scarcity in this district, the cost of production of bricks was too high for competition with outside firms. Lately the Haileybury Brick and Tile Company made the discovery that the finely ground diabase, so plentiful at Cobalt, could be used in place of sand. By experimentation, a suitable mixture of ground diabase and clay has been found and bricks much superior to those formerly produced are now being made. The increased cost of production has been more than overcome by the increase in number of good bricks obtained.[1]

---

[1] Ont. Bur. Min. Reports, Vol. XVI, Part 3, 1907, p. 135.

Limestone

Some of the limestone of the area is suitable for building, for the making of lime and for use in the manufacture of paper pulp.

Limestone (Lockport) cliffs at Dawson Point, Lake Timiskaming.

Farr Quarry.—Just south of the map area at Haileybury, in lot 2, concession III, Bucke township, is the Farr quarry, which has been shipping Trenton limestone to the Abitibi Pulp and Paper Company's plant at Iroquois Falls for a number of years. The limestone is used in a sulphide plant for the manufacture of paper pulp. The limestone has been shipped continuously from 1915 to 1921, inclusive, the total value of the output being in the neighbourhood of $22,082.

Lime.[2] All the lime that has been produced in the area has been made from the Lockport formation. At present a kiln is situated west of Liskeard and owned by Mr. W. Taylor [and shown on the accompanying map] is the only producer of lime in commercial quantities. Analyses of the limestones gave the following results:

Analyses of Limestone from Haileybury and Liskeard.

	Farr's Quarry. Per Cent.	Taylor's Quarry. Per Cent.
Insoluble residue	5.06	2.96
Aluminum and iron oxide	0.87	1.87
Calcium oxide	44.81	31.98
Magnesium oxide	5.90	10.86
Carbon dioxide	42.40	51.85
Total	99.40	99.52

G. S. Hume, collector and analyst.

---

[1] Sum. Rep. Geol. Surv. Can., 1916, p. 191, by G. S. Hume.

[2] Ibid, pp. 191, 192.

W. G. Miller[1] found a sample of limestone from the Farr quarry on analysis to yield as follows:—insoluble residue 1.60; ferric oxide and alumina .66; lime 29.50; magnesia 21.59; carbon dioxide 46.84; sulphur trioxide .70; total 100.89 per cent.

David Bass of Thornloe has a small outcrop of Silurian (Lockport) limestone on his farm in the south part of lot 1, concession II, Armstrong township, from which some lime is made at times for local use. Fragments 5 inches across are burned in a small kiln which has a capacity of 200 bushels in 96 hours.

Lime kiln on lot 1, concession II, Armstrong township.

Building Stone.—Rocks of both the Trenton and the Lockport formations have been used as building stone to some extent.

In Haileybury several buildings, chief among which is the cathedral, have been made of stone taken from Farr's quarry, west of the town. The stone, which is Trenton in age, is of a bluish grey colour on the fresh surface and of a pleasing appearance, but, owing to the great thickness of the individual beds, the stone is not readily obtained in blocks of the proper size and with smooth surfaces.

A good quarry for building stone has been opened on the east side of Mann or Burnt island, from which stone was taken to build the public library of New Liskeard. The stone is buff to cream-coloured and occurs in the quarry in uniform beds six to eight inches thick. Jointing, too, is well developed and fairly regular, so that waste in quarrying is not excessive. Owing to the ease with which the stone may be extracted and to the fact that it can be transported by boat to any of the towns around the lake, this quarry should become of considerable commercial importance in the near future.[2]

Limestone in various parts of the area has been used locally for building foundation purposes.

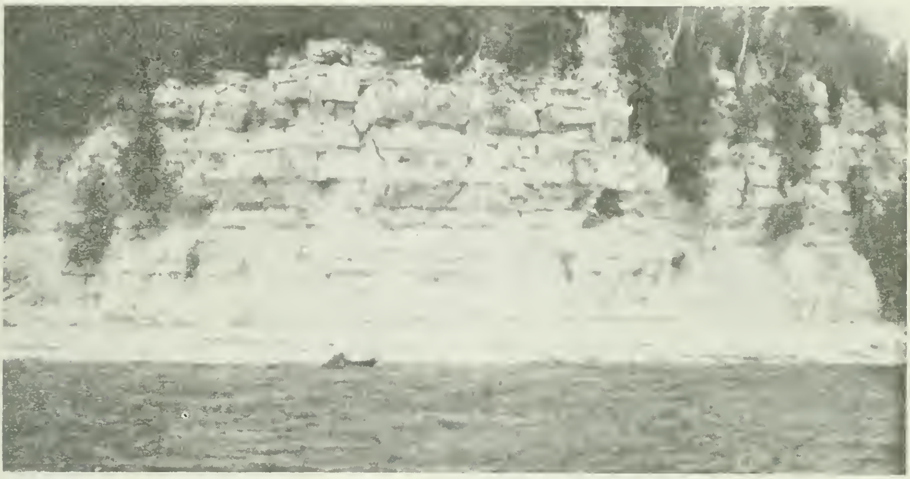
---

[1] Ont. Bur. Min. Report, Vol. XIX, Part 2, p. 107.

[2] Sum. Rep. Geol. Surv. Can., 1916, p. 192, by G. S. Hume.

Quartzite

Silica Granite Products Co.—This company owns the south half of lot 3, concession III, Henwood township, which is 3½ miles from a railway. Much of the lot is covered by a grey Animikie quartzite, which is common in many townships of the area. It could not be learned why a plant, consisting of a boiler, jaw crusher and trammels, had been installed at this point, when similar rock occurs nearer railway transportation.



Outcrop of Silurian (Lockport) limestone at Dawson Point, Lake Timiskaming.

Peat Bog

Maybrooke.—This bog is on the Temiskaming and Northern Ontario railway between mileages 121 and 123 in Kerns and Harley townships. The surveyed outline of the bog, as furnished by S. B. Clement, chief engineer for the railway, has been placed on the accompanying map. It contains approximately 1,281 acres, namely:—

Acres	*Depth of Peat, ft.*	*Volume in Cubic Yards.*
232	Less than 5; average 4.	1,498,000
671	5 to 10; average 7.	6,890,000
378	10 to 15; average 11.	6,705,000

The peat is composed principally of sphagnum, heavily mixed with carex, eriophorum and other plants.[1]

Sand and Gravel

The sand and gravel areas are outlined on the accompanying map. Wherever convenient, the gravel has been used for road dressing and construction purposes. Enormous quantities have also been used for railway ballast. A fine sand, containing some clay and suitable for moulding purposes, occurs on the farm of J. Haddoux, lot 3, concession I, Kerns township. One carload has been shipped to the Wabi Iron Works at Liskeard.

---

[1] The Mining Industry in that part of Northern Ontario served by the Temiskaming and Northern Ontario Railway, 1919, by A. A. Cole.

Water Supply

In the large plain extending from Liskeard to Englehart, the Paleozic limestone is overlain by 100 to 250 feet of clay, in portions of which surface well water is scarce, particularly since the forest has been largely cleared away. Numerous deep wells have been drilled in portions of the area from which abundance of water is obtained. In many wells the water rises to a point near the surface and is pumped, while in others the water has a constant flow. Some wells flow during the spring and autumn and are pumped during other seasons. Thornloe obtained an artesian well with a flow of 6 gallons per minute after drilling through 230 feet of clay, 8 feet of quicksand and 35 feet of grey limestone.[1] The water supply of the town of Liskeard comes from several deep wells. In most parts of the area where boring has been done a supply of water is usually obtained.

Hydro-Electric Power

In 1914, in the early stage of development of the Tough-Oakes gold mine to the north of this area, a 1200 horse power hydro-electric plant was built at the south end of Long lake at Charlton. The power is transmitted at 33,000 volts on a three-phase transmission line to Kirkland Lake, part of the line being shown on map, Number 31b. The Charlton plant also furnishes light, heat and power to the towns of Charlton and Englehart, and to some farms. Following upon further development, the Northern Ontario Light and Power Company bought the Charlton plant and also extended its transmission line from the sub-station at Cobalt to Kirkland Lake, a distance of 65 miles. Thirty-nine miles of this transmission line is also shown on the accompanying map-sheet.[2]

A small power was developed on the Wabi river in Dymond township by the town of Liskeard; however, this plant was taken over by the Northern Ontario Light and Power Company and closed down.

A power has been partially developed on the west end of Wendigo lake in Marter township by the Canadian Associated Goldfields interests. The plan was to dam the outlet of Wendigo lake and allow the water to pass through a flume, one mile in length, which would empty into the Blanche river below a series of rapids and falls, thus attaining a head of 135 feet. Some rock excavation was done in 1920, and in 1921.

Approximately 2,000 horsepower could be developed on the north branch of the Blanche river in lot 2, concession IV, Marter township, where a total operating head of 138 feet is available. The discharge of the river on May 6th, 1915, was 552 cubic feet per second.

---

[1] Mining Industry in that Part of Northern Ontario Served by the Temiskaming and Northern Ontario Railway, by A. A. Cole, 1914, p. 65. Logs of wells drilled at other stations by the T. & N. O. Railway are given in Mr. Cole's report for the years 1915 and 1916.

[2] On October 4th, 1922, a large part of the Blanche River area was visited by a disastrous fire, resulting in the loss of some 43 lives. Many farmers were burning slash, brush and stumps as is customary at this season. Deciduous trees had shed their leaves and these were dry as tinder. Following a protracted dry period a high wind sprang up, fanning fires which spread with great rapidity. Houses and farm buildings, several villages, the town of North Cobalt and the greater part of the town of Haileybury were destroyed. Haileybury was burned in two hours, while Liskeard was saved by a sudden change in the high wind. In addition, twelve miles of electric transmission line, which supplied the Kirkland Lake gold area with power, was destroyed, causing the loss before repairs were completed of a full month's output. The localities hardest hit were Casey, Evantuel and intervening townships. Settlements along the Elk Lake branch of the T. & N. O. railway were also destroyed. In consequence many of the buildings shown on the accompanying map (No. 31b) no longer exist.

INDEX

Vol. XXXI, Part 3

PAGE

- Agglomerate ... 1, 5
- Agricultural land ... 1, 3, 9
- Algoman. *See* Laurentian.
- Amygdules ... 4
- Analyses
  - Andesite: dactite ... 5
  - Limestone ... 17, 18
- Andesite ... 4-6, 10
- Animikie series ... 4-7, 19
- Aplite dikes ... 13, 14
- Armstrong tp. ... 9, 18
- Auld tp.
  - Rocks ... 4-7
  - Silver ... 1, 2, 8, 13-15
- Basalt ... 4, 10
- Bass, David ... 18
- Batholiths ... 6, 12
- Bayly tp.
  - Rocks ... 4-6
  - Silver ... 16
- Beauchamp tp.
  - Agricultural land ... 3
  - Morainic ridge ... 9
  - Rocks ... 3-5
- Biotite granite ... 6
- Biotite schist ... 5
- Blanche river
  - Clay ... 3
  - Gold ... 12
  - Profile of part ... 21
  - Rocks ... 2, 8
  - Waterpower ... 20
- Black River formation ... 2, 8
- Borgford, George ... 11
- Borgford gold claim ... 10, 11
- Bradley-Donaldson silver mine ... 15
- Brethour tp. ... 3, 5, 9
- Brick clay ... 9, 16
- Bryce tp.
  - Gold ... 1, 5, 10-12
  - Morainic ridges ... 9
  - Rocks ... 4-7, 10
- Bucke tp. ... 17
- Building stone ... 8, 18
- Burnt (Mann) island ... 18
- Burrows, A. G. ... 2
- Bushnell silver mine. *See* Casey-Cobalt silver mine.
- Calcite veins ... 13
- Canadian Associated Goldfields ... 20
- Cane tp.
  - Clay ... 9
  - Rocks ... 3-8
  - Sand plain ... 9
  - Silver ... 1, 2, 8, 13
- Cane Silver Mines ... 13
- Casey mt. ... 15
- Casey tp. *See* Casey-Cobalt.
- Casey-Cobalt silver mine
  - Notes ... 15
  - Ore, origin ... 8
  - Production ... 1
- Cataract formation ... 3

PAGE

- Chamberlain tp.
  - Agricultural land ... 3
  - Gold: rocks ... 5, 6, 12
- Charlton.
  - Agricultural land ... 3, 9
  - Rocks ... 6, 12
  - Waterpower ... 20
- Chlorite schist ... 4
- Clarke, A. R. ... 1
- Clay ... 1-3, 9
- Clement, S. B. ... 19
- Cobalt, Ont. ... 17
- Cobalt bloom ... 8, 14, 16
- Cobalt series ... 10
- Cole, A. A. ... 20
- Conglomerate ... 6, 7, 10
- Copper pyrites ... 16
- Dacite ... 4, 10
- Dack tp.
  - Agricultural land ... 4
  - Gold prospecting ... 1, 12
  - Rocks ... 4, 5
- Dawson pt. ... 8, 17
- Diabase ... 5-8, 14
  - *See* Nipissing diabase for bricks ... 17
- Dolomite. *See* Lockport formation.
- Dymond tp. ... 7, 20
- Earlton ... 3, 6
- Englehart ... 8, 9
- Erythrite. *See* Cobalt bloom.
- Farm land. *See* Agricultural land.
- Farr limestone quarry ... 17, 18
- Feldspar porphyry ... 6
- Fire ... 20n
- Galena ... 16
- Geology ... 3-10
- Gold ... 1, 10-12
- Glacial deposits. *See* Pleistocene.
- Glacial striæ ... 9
- Granite ... 6, 10
- Granophyre ... 8
- Grant gold claim ... 12
- Gravel, economic ... 19
- Greenwood, W. ... 1
- Haddoux, J. ... 19
- Haileybury.
  - Brick clay ... 16
  - Limestone, analysis ... 17
  - Rocks ... 2, 8
- Haileybury Brick and Tile Co. ... 17
- Harley tp. ... 9, 19
- Heisey, K. B. ... 1
- Henwood tp.
  - Clay: sand ... 9
  - Quartzite ... 3, 6, 19
- Hilliard tp. ... 9
- Hitchcock, W. R. ... 15
- Hitchcock silver claim ... 14
- Hore, R. E. ... 7, 16
- Hornblende schist ... 4
- Hudson tp. ... 3, 7, 8
- Hume, G. S. ... 2, 8
- Hydro-electric power ... 20

PAGE

- Ingram tp.
  - Clay 9, 16
  - Cobalt bloom 8, 16
- Iroquois Falls 8
- Jeffrey, W. H. 15
- Judge 9
- Kearney, D. 1
- Keewatin formation 2-6, 9, 10
- Kenabeek 8, 15
- Kenabeek Silver Mines 15
- Kerns tp.
  - Clay: peat 19
  - Rocks 3, 8
- Kettle holes 9
- Keweenawan formation 4, 7, 8
- Knight, C. W. 14
- Krugerdorf rapids 21
- Laurentian (Algoman) 4, 6, 10
- Lava 1, 4, 5
- Leslie, H. T. 1
- Lime 17
- Limestone 8, 17, 18
  - *See also* Trenton limestone.
- Limestone, economic 17
- Liskeard (New Liskeard).
  - Agricultural land 1, 9
  - Brick clay 16
  - Fault scarp 8
  - Limestone, analysis 17
  - Waterpower for 20
- Lockport formation 3, 8, 17, 18
- Long l. near Charlton 3, 20
- Lundy tp. 6, 7
- McNeill, W. K. 1
- McOuat, Walter 2
- McPherson farm 12
- Mallard lake 16
- Mann (Burnt) island 18
- Maps
  - Blanche R. area (geol.). With Rept.
  - Index 1
- Marquis tp. 6
- Marter tp.
  - Gold 1
  - Rocks 4
  - Sand areas 3, 9
  - Waterpower 20
- Mica schist 4, 5
- Miller, W. G. 2, 8
- Morainic deposits 9
- Mulligan tp.
  - Cobalt bloom 8, 16
  - Rocks 5-7
- New Liskeard. *See* Liskeard.
- Niagara formation 2
- Niccolite 13
- Nipissing diabase 2, 3, 6, 7, 10

PAGE

- Northern Ontario Light and Power Co. 20
- Ontario Solid Silver Mines, Ltd. 14
- Ordovician. *See* Trenton limestone.
- Pacaud tp. 6
- Paleozoic 3, 8
- Parker gold claim 12
- Parks, W. A. 2
- Peat 19
- Pense tp.
  - Cobalt bloom 8, 16
  - Rocks 5, 6
- Pillow structure 4
- Pleistocene 3, 9
- Pontiac series 5
- Porphyry 6
- Pre-Cambrian 3-8
- Quartzite 3, 6, 19
- Quartz porphyry 6
- Quesnell gold claim 12
- Recent deposits. *See* Pleistocene.
- Robillard tp. 3, 4, 6
- Rothwell, T. E. 1
- Sand 3, 9
  - Economic 19
- Savard tp. 3
- Scott gold claim 12
- Shepp silver claim 14
- Silica Granite Products Co. 19
- Silver. *See also* Casey-Cobalt.
  - Mining 13-16
  - Wendigo lake 1, 2
- Silurian 3, 8, 18
- Skead tp. 5
- Smaltite 13, 14
- Soil. *See* Agricultural land.
- Sphalerite 16
- Striæ. *See* Glacial striæ.
- Superficial deposits. *See* Pleistocene.
- Table of formations 3, 4
- Taylor, Wm. 17
- Temiskaming and Northern Ontario Ry. 19
- Thelma Mining Co. 10
- Timiskaming lake 2
- Topography 3
- Trenton limestone 3
- Triangle Silver Mines 14, 15
- Wabi river 20
- Waterpower; water supply 20
- Wedge, J. A. 1
- Wendigo lake
  - Rocks 6, 7
  - Silver 1, 2
  - Waterpower 20
- Williams, M. Y. 2, 8
- Zinc. *See* Sphalerite.

PROVINCE OF ONTARIO
DEPARTMENT OF MINES

HON. H. MILLS, MINISTER OF MINES — THOS. W. GIBSON, DEPUTY MINISTER

THIRTY-FIRST ANNUAL REPORT
OF THE
ONTARIO DEPARTMENT OF MINES
BEING
VOL. XXXI, PART IV, 1922

Fourth Report
OF
JOINT PEAT COMMITTEE

By B. F. Haanel, Secretary

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY OF ONTARIO

TORONTO
Printed by CLARKSON W. JAMES, Printer to the King's Most Excellent Majesty
1923

CONTENTS

Vol. XXXI, Part IV.

Page
Introduction 1
Preparations for 1921 Operations .. 2
Operations during 1921:
  Improved Plant No. 4 2
  Portable Belt Conveyor 2
Plant No. 2—Moore Plant 5
  Erection of Plant on Bog 6
  Novel Features of the Moore Machine 7
  Drying Field Required for Season's Output 9
  Harvesting 10
  Difficulties Encountered and Improvements Made 10
  Conclusions Reached at the End of 1920 10
  Table I—Operation of No. 2 or Moore Plant 12
  Table II—Summary Trouble Sheet, Plant No. 2 13
  Costs 14
    A. —Capacity of Machine 15
    B. —Production Cost 16
Costs—*continued.*
    C. —Overhead 16
    D. —Cost if operated by Self-Contained Steam Plant 17
    E. —Cost if driven by Semi-Deisel Engine 17
  Farmers' Plant 18
  Macerating 18
  Loss of Peat Fuel through Fire.. 19
  Sale of Manufactured Fuel 20
  Harvesting 21
  Meteorological Observations with reference to Drying 22
  Outline of Investigation for 1922. 24
APPENDIX
Development of Peat Machinery ... 25
Necessity for further Government Operation 26
Cost of Manufacturing Fuel with the Combination Plant 26
Costs 27
Market 28
Plant No. 3, Small Peat Plant 28

ILLUSTRATIONS

Fig. 1.—Belt Conveyor in place for operation 3
Fig. 2.—New Spreader attached to Belt Conveyor 4
Fig. 3.—Another view of Belt Conveyor system, Excavator in distance 5
Fig. 4.—One of the eleven Caterpillar elements 6
Fig. 5.—Peat Fuel laid on the field by the new machine 7
Fig. 6.—Belt Conveyor and Spreader 8
Fig. 7.—Plant No. 2 in operation 8
Fig. 8.—Near view of Spreader; also Cutting Device 9

DIAGRAM

General plan of operation for single unit, Anrep-Moore machine peat manufacturing plant 23

FOURTH REPORT OF JOINT PEAT COMMITTEE

By B. F. Haanel, Secretary.

Introduction

The Peat Committee shortly after appointment early in 1918, carefully examined all existing reports and records concerning the manufacture of peat into a domestic and industrial fuel, and concluded that the air-dried machine peat process was the only economic one known to exist which gave promise of ultimate success when employed under conditions obtaining in Canada. To adapt this process to Canadian conditions, the Committee found that new types of peat manufacturing machinery, capable of performing the several operations required in the course of manufacture, had to be developed. Consequently, the investigation inaugurated by them resolved itself into: first, the design and construction; second, development, and third, operation of machines capable of operating under severe and adverse conditions, with the employment of the minimum number of labourers and with the minimum charge for repairs and maintenance.

The Preliminary Reports issued by the Peat Committee from their appointment in 1918, up to and including the year 1920, dealt with the design, construction, development and operation of the two different types of peat machines —designated as plants Nos. 1 and 2—which, in the opinion of the Committee, offered the greatest promise of success. The investigation also included the design, construction and development of a small peat machine capable of being operated by one man and two boys, suitable for the manufacture of peat fuel on a small scale by individual farmers, or groups of farmers or small communities. This machine, during this period, also passed more or less successfully through the stages of design, construction and development.

As a result of the progress made up to the end of 1920, the Committee were in a position to make in their Preliminary Report for that year the statement: "Although it is not possible for the Peat Committee to state at this time that Peat Fuel can or cannot be manufactured in Canada on a commercial basis, the results of the investigation so far conducted enable them to arrive at the following conclusions:—

(1) That the Anrep plant (No. 1) as it stands is in no sense commercial.

(2) That the Moore plant (No. 2) under certain conditions can be employed commercially for the manufacture of Peat Fuel.

(3) That the Anrep excavating element is the superior of the two and the logical one to employ, while

(4) The Moore spreading system is far more efficient and is the logical spreading system to employ."

Based on these conclusions, recommendations were made for conducting the investigation through the season of 1921, and for concluding same during the season of 1922-3. These recommendations were as follows:—

(1) That a portable belt conveyor be constructed for operating in conjunction with the Anrep excavating element for the purpose of combining the best elements of the two types of machines.

(2) To develop and commercially try out a small Farmer's Peat machine.

(3) To operate the Moore plant throughout the entire working season on a strictly commercial basis with the least number of men and without the supervision of the expert staff, in order to obtain valuable information and data concerning overhead costs, actual costs of laying fuel on the field, harvesting same and transporting to stock pile and loading into cars for shipment: also to determine the loss in time through breakages, etc. Further, it was desirable that this machine be operated in order that sufficient peat fuel be manufactured to supply the market already created.

Preparations for 1921 Operations

This report is concerned chiefly with the recommendations just cited, and includes a somewhat detailed analysis of the results obtained with Plant No. 2, which was operated on a strictly commercial basis during the entire season in accordance with the above programme. This plant was not put into perfect condition inasmuch as this would have involved the redesigning and reconstructing of the caterpillar elements, an expense which the Peat Committee did not feel warranted in incurring, hence the results obtained are inferior to what would be expected were these known defects of the machine removed.

Operations during 1921

Improved Plant No. 4

On June 1st the first car load of the new conveyor parts arrived at Alfred station, and during the same month the remainder of the conveyor parts arrived at the bog. The assembling of the conveyor parts was immediately begun, and the installation of the entire plant was sufficiently far advanced on August 5th to enable the conveyor to be turned over under its own power, and on August 20th, excavated peat was delivered to the belt of the portable conveyor. The time from August 20th to August 26th, was spent in making adjustments in order to permit the belt conveyor, spreader and excavator to work in harmony, and on August 26th, a very fair demonstration of the operations of the entire plant was made in the presence of the Peat Committee and others.

Portable Belt Conveyor

The portable belt conveyor, which takes the peat from the excavator and delivers it continuously to the spreader, is of novel design, and may even be described as a daring venture on the part of those responsible for the conception of the idea. Nothing of its kind had ever before been constructed, and although stationary belt conveyors of longer spans are in successful use, the attempt to employ a portable belt conveyor of the dimensions of this conveyor has never been made, so a great deal of credit is due to the engineer of the Peat Committee and to those responsible for the carrying out of the design and construction for the remarkable success which was achieved almost on the very day the conveyor was completely assembled.

The conveyor is 850 feet long, and is composed of ten 85-foot latticed, boxed girder sections connected together forming a flexible bridge member which is carried on eleven caterpillar elements, all of which are operated from the main caterpillar near the excavating element. This bridge supports a rubber-covered belt conveyor, 850 feet between centres, thus making a total length of belt of

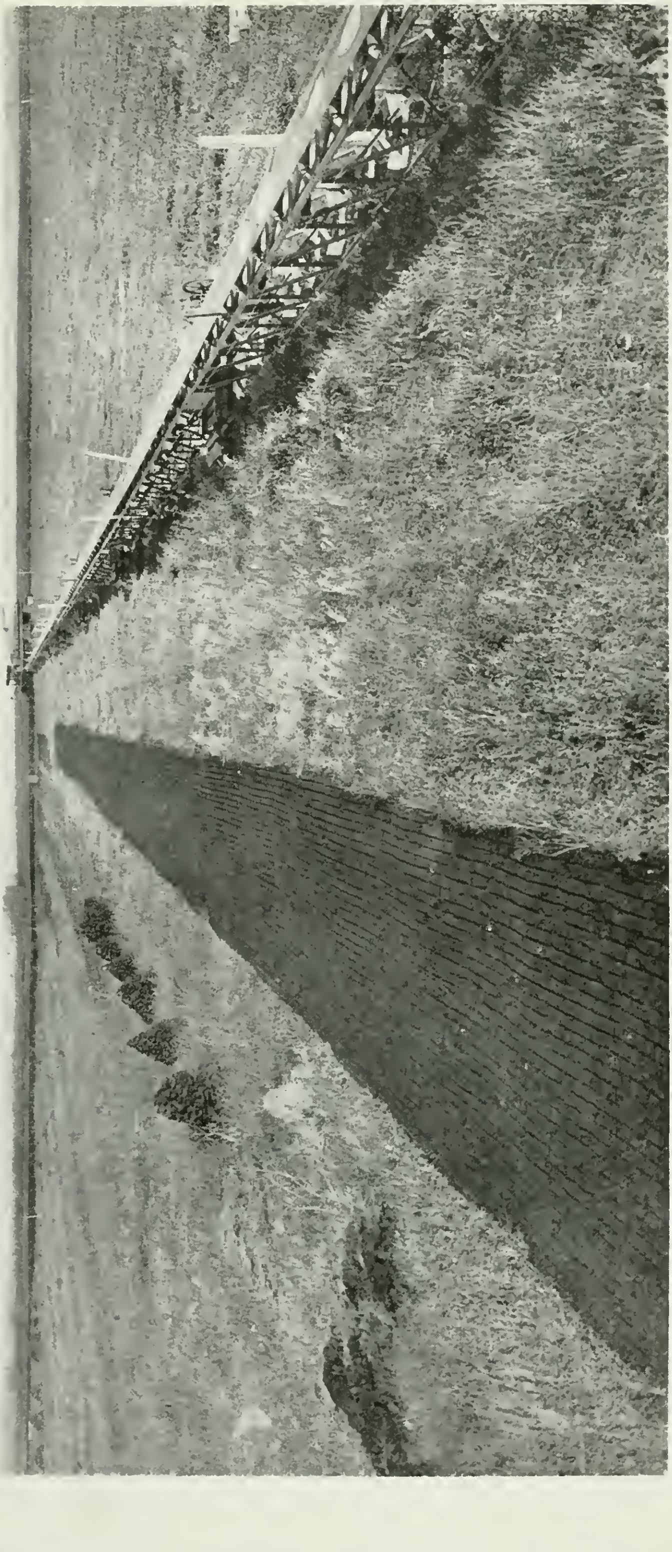


Fig. 1.—Belt Conveyor in place for operation.

1,700 feet. Fears were entertained that the conveyor would get seriously out of line and throw the belt off when attempts were made to move it under its own power over the field, but these fears proved entirely unfounded. In order to lay on the field ten tons an hour of standard peat fuel it is necessary to move the belt conveyor every 1¼ hours a distance of 13 feet 6 inches parallel to the line of travel of the excavating element. and this means a lateral movement of 108 feet in a working day of ten hours. The conveyor system in fact was put through a very severe test, a more severe test than it will ever be called upon to withstand in actual practice, and not only did it maintain its line, but in general, its behaviour far exceeded the expectations of its designers.

The spreader which was designed and constructed for use with this conveyor system was based upon the experience and results obtained with the spreader used on the Moore system. This spreader also had a very severe trial, and proved entirely satisfactory with the exception of a few minor mechanical details which will be changed.

The quality of the peat laid on the field by this improved plant is better than anything that has ever been obtained before at Alfred.

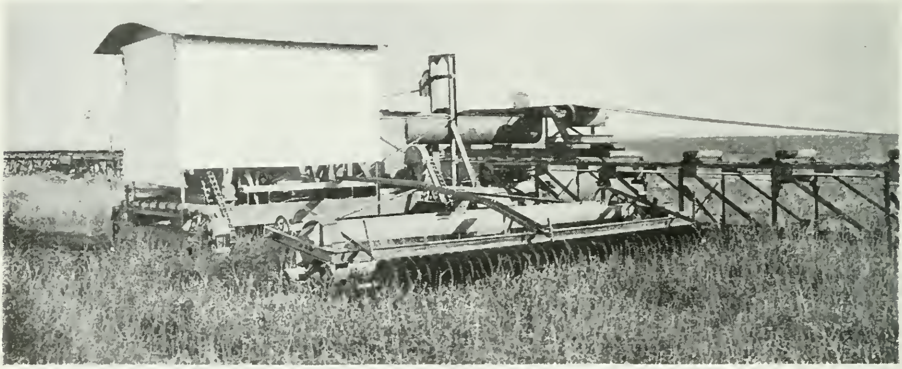


Fig. 2.—New Spreader attached to Belt Conveyor.

Fig. 1 shows the belt conveyor in place for operation. Fig. 2 shows the new spreader attached to the belt conveyor. Fig. 3 is another view of the belt conveyor system, and excavator in the far distance, and shows the unloading device for delivering the peat from the belt into the hopper of the spreader. Fig. 4 shows one of the caterpillar elements of which there are eleven, and also the take-up pulley at the extreme outboard end of the conveyor. Fig. 5 shows the peat fuel which was laid on the field with this new machine. This figure shows very clearly the effect of the improved longitudinal and cross cutters. It will be seen that the peat blocks are separated by a considerable space, and that this increases the drying surface over that obtained with former methods for cutting. This improved method of longitudinal and cross cutting, it is believed, will greatly improve the quality and resisting properties of the peat, as well as materially reducing the time required for drying down to 25 per cent. or 30 per cent. moisture.

Plant No. 2.=Moore Plant

This plant was constructed from original designs prepared by E. V. Moore, submitted to the Minister of Mines of the Federal Government before the formation of the Peat Committee, who decided that it should be constructed. In designing this plant Mr. Moore's objective was the reduction to as great an extent as possible of the number of labourers required to operate the plant, and his design shows a great many novel features which it was believed would realize this end. Neither this plant nor any plant of similar design, had previously been constructed, and it therefore devolved upon the Government and later the Peat Committee to construct and develop it into a successful machine. The advantages which were claimed for this design at the time it was presented were:—

(1) Lower cost of plant for a given output as compared with the Anrep system.

(2) Reduction in number of men required to operate, namely seven men compared with fifteen or more for the Anrep system.

(3) Four boys required to perform the operation of cubing, which required not less than twelve workers with the Anrep system.

(4) Number of men required for harvesting reduced by one-half.

(5) Fuel not loaded on railway cars automatically left in storage piles instead of remaining spread over the drying field.

(6) No delays incurred in moving tracks or bringing machine back to starting point, which delays are responsible for the loss of 25 to 30 per cent. of the total working time, when the Anrep system is employed.

(7) Extremely direct route of the peat from the working face to the drying field will permit using much less transmission machinery, and will provide more regular feed to the macerator and, therefore, increase its output.

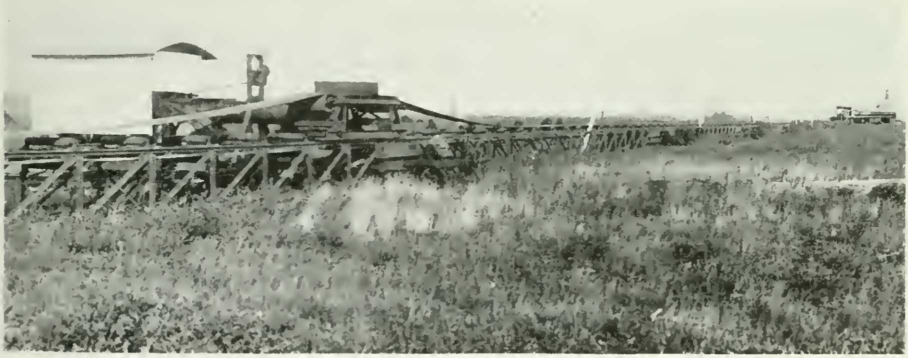


Fig. 3.—Another view of Belt Conveyor system, Excavator in distance.

The Government, and later the Peat Committee, after carefully considering these claims were convinced that the design possessed sufficient merit to warrant experimenting with a full-sized unit, and consequently the construction of this machine was authorized at the same time as the Anrep plant.

Erection of Plant on Bog

Although the contract to construct this plant was given sufficiently early in the season to insure its erection on the bog in time to give the plant a complete mechanical try-out during the summer of 1918, failure on the part of the contractors to meet their obligations made it impossible to begin erection until late in the Fall of 1918. Consequently it was impossible to investigate the mechanical behaviour of the plant until the spring and summer of 1919.

During this year, the Moore plant had a severe mechanical trial in the course of which a certain amount of peat was manufactured. This trial disclosed many weaknesses and faults in the design, which were remedied to as great an extent as possible during the following winter. In 1920, the Moore plant was operated for the manufacture of peat fuel throughout the entire working season. This season's investigation demonstrated to the satisfaction of the Peat Committee that the original claims enumerated above were not borne out in every particular. For example, it was found that the harvesting operation could not be performed with this machine without seriously reducing its capacity for making peat fuel. But a still more serious defect was disclosed, namely, the excessively long working face which this type of machine requires for laying down a season's production of peat fuel. In order to lay down one ton of peat fuel, the Moore machine must travel a linear distance of 56 feet. This not only means that the entire weight of the machine, excavating element, conveyor and spreader must be moved that distance, but also that in performing a season's work it will be necessary for the machine to travel approximately 60 miles. This is a very severe handicap for any machine, inasmuch as the wear and tear on the entire plant to perform this excessive travel would be abnormal. Moreover, the fact that a very long working face, approximately two miles in length, is required to lay down a season's production of fuel, will limit its employment to only a very few bogs. Even on bogs where such a machine could be employed, it would be impossible to operate economically more than one unit to advantage.

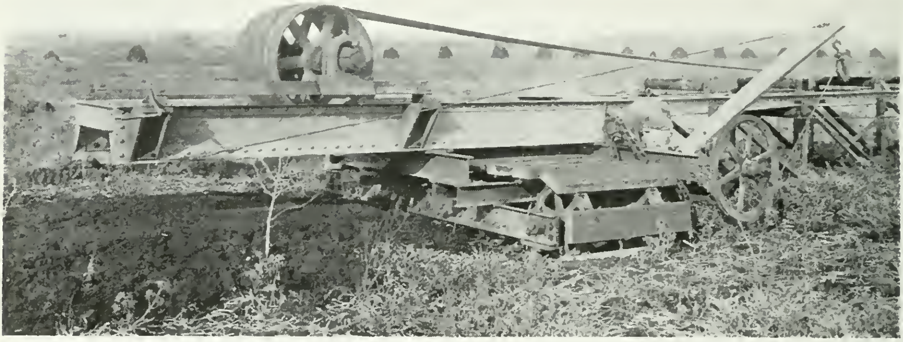


Fig. 4.—One of the eleven Caterpillar elements.

Another defect should be mentioned, namely, the difficulty of keeping the machine on the line of excavation. It has been observed that in order to keep the machine on the line of excavation and insuring that the excavator buckets remove a constant quantity of peat, a very skilful operator is required, and even then the quantity of peat excavated in a unit of time may not be constant.

Novel Features of the Moore Machine

A novel feature possessed by this machine is the method employed for transporting the excavated peat from the macerator to the spreader. This is accomplished by a belt conveyor which is flexibly attached to the middle of the main platform carrying the excavator and macerator. This belt conveyor is about 180 feet long, and is formed of a box girder about 30 inches square. The inside end of this girder is attached to the main platform, the balance of the weight being supported on a caterpillar element situated approximately 100 feet out, which is operated in unison with the caterpillars on the main machine through the medium of a power shaft connected to the caterpillar-driving mechanism on the main machine. The spreader is attached to this belt conveyor at any desired position, and is dragged along by the main machine. When one row is completed, the direction of the main peat machine is reversed, and the spreader is removed to the opposite side of the girder and shifted the required distance along the conveyor. After this row is completed, the main machine is again reversed, and the operation repeated until the requisite number of rows representing the season's output are laid on the field.

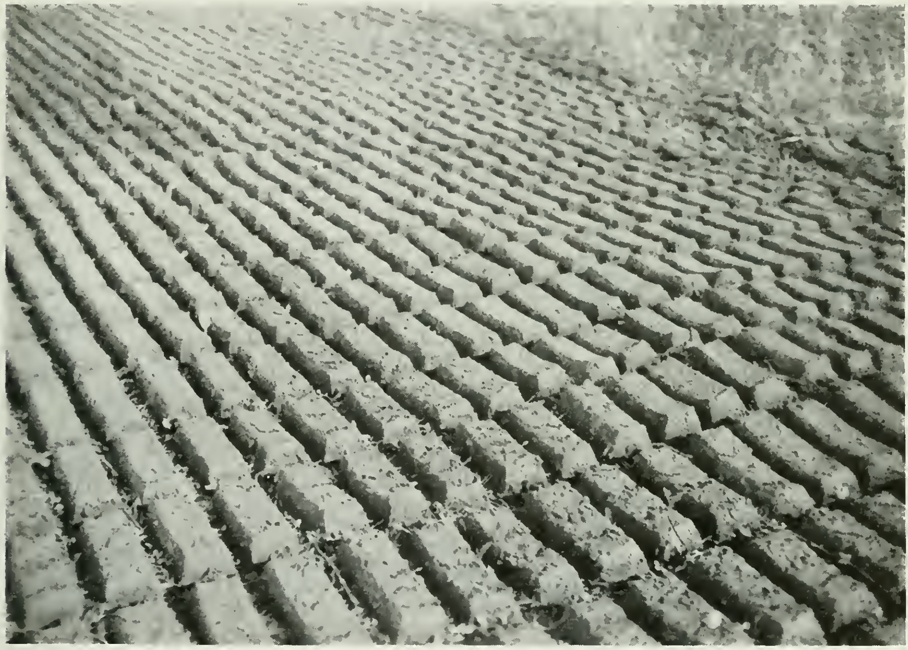


Fig. 5.—Peat Fuel laid on the field by the new machine.

Fig. 6 shows the belt conveyor with the spreader in position near the end farthest removed from the line of excavation, and the entire plant at the end of the working face ready to be reversed. This figure also shows clearly the peat laid on the ground. Fig. 7 is a general view of the No. 2, or Moore plant, in operation. Fig. 8 shows a close-up view of the spreader in the position indicated in Fig. 6 and clearly illustrates the operation of the cutting devices. It also shows the

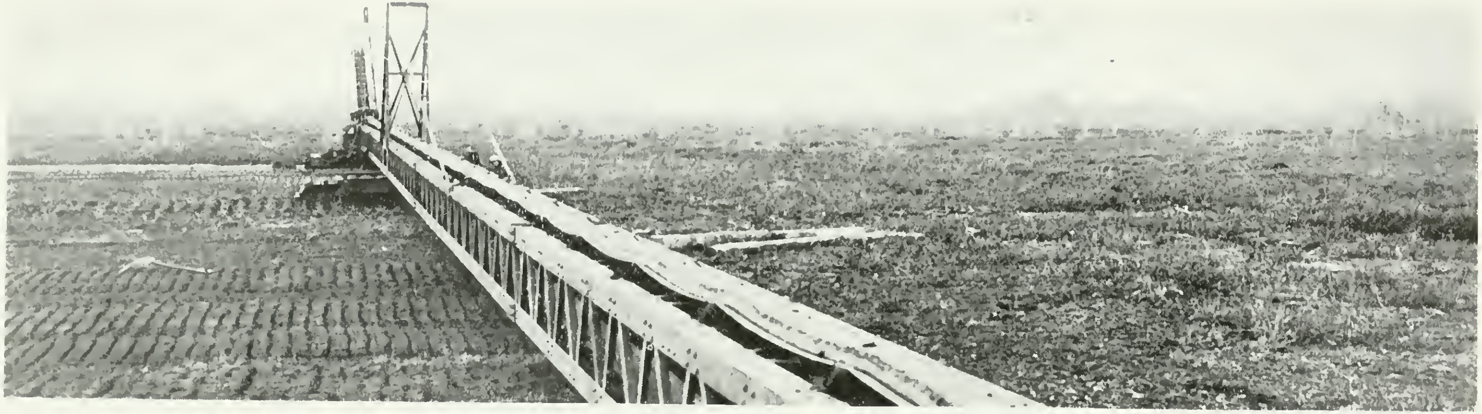


Fig. 6.—Belt Conveyor and Spreader.

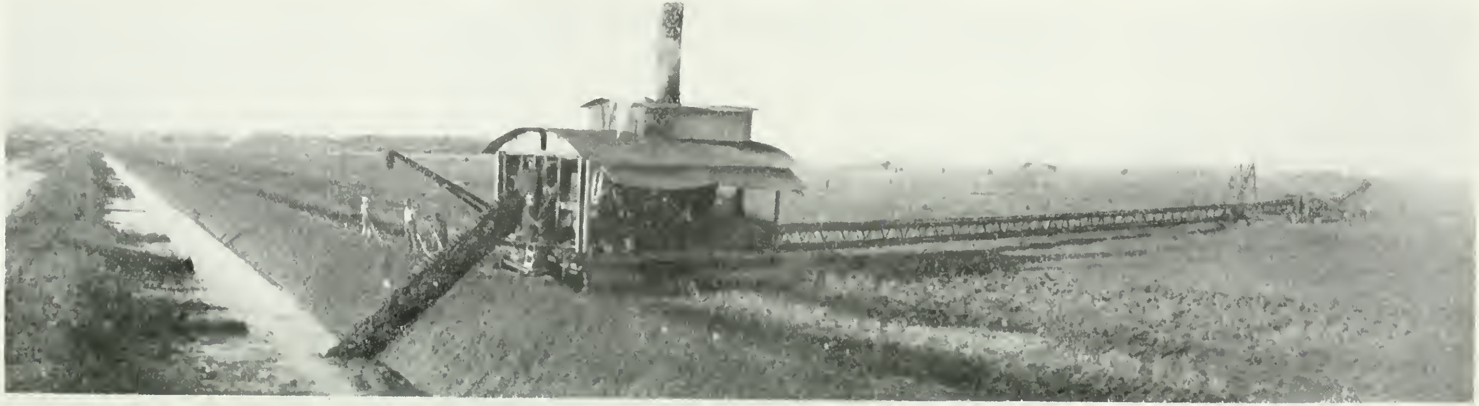


Fig. 7.—Plant No. 2 in operation.

position of the spreader when the maximum number of rows is laid. The elevator at the extreme end of the girder is used to convey the dried peat to stack or small train cars.

When the last row is completed the machine must either stop, or else the first row laid down must be sufficiently dry for harvesting, in order that the spreader may be placed in its original position and the operation of laying down peat again proceeded with as described. Fig. 7 shows also the device for unloading the peat from the conveyor belt to the hopper situated at the centre of the spreader. This hopper delivers into a box the full width of the spreader (12 feet) which is provided with a 14-inch standard spiral conveyor, one half of which is right hand and the other, left hand, both sections tapering from the full size at the centre to practically nothing at the ends. This spiral is rotated by power received from the transmission shaft which extends the full length of the bridge work, and insures that the peat fed in the hopper will be spread in a sheet of uniform thickness. The depth of the opening for the discharge of the peat on the field may be adjusted from 3 inches to 6 inches, and this opening extends over the full length of the box. By means of this regulation the thickness of the sheet of peat laid on the bog can be varied to suit conditions.

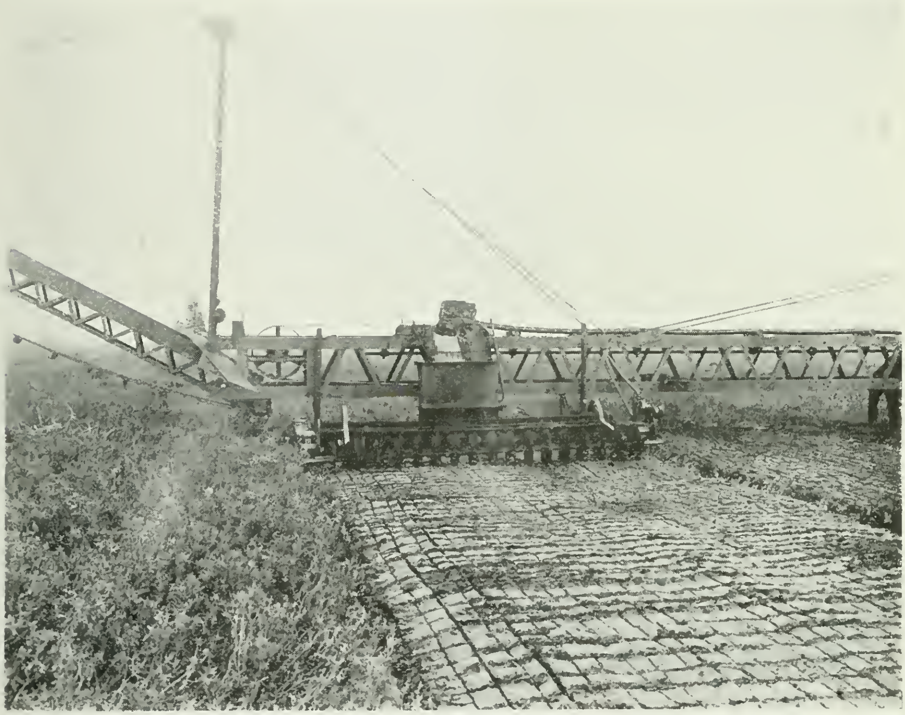


Fig. 8.—Near view of Spreader; also Cutting Device.

Drying Field Required for Season's Output

For an average production of 60 tons per day of ten hours, this machine must travel 3,360 lineal feet, and since a maximum of forty days is required for complete drying, it is necessary to provide a drying field which will permit the laying out of 120,000 feet of spreader section, that is 120,000 feet by twelve feet the width of the spreader times the depth of the peat spread. The belt conveyor is of sufficient length to provide for the laying down of 12 rows. The drying field for ten hours per day operation should, therefore, be 10,000 feet long in order to insure the complete drying of an average production of 60 tons of fuel per day. This is one of the chief drawbacks of the Moore plant. The working face provided for this machine at Alfred was 8,000 feet long, but this did not permit of the complete drying of the fuel and at the same time the production of the quantity of peat fuel for which the machine was designed.

Harvesting

When the machine was developed on paper, it was considered possible to employ the above conveyor for harvesting the dried peat at the same time that the peat slop was being laid on the field, but this operation it was found could not be efficiently performed without further experimentation. In short, all attempts to employ the conveyor for harvesting the dried peat fuel resulted in a decrease in the quantity of peat produced. Other methods of harvesting were consequently resorted to.

Difficulties Encountered and Improvements Made

The most serious difficulties encountered in connection with the operation of the Moore plant were occasioned by the caterpillar elements. When these were designed the engineer had very little data to guide him, since no machine capable of performing the operation required of a peat machine had ever before been designed for travelling over a spongy surface on caterpillar elements, consequently, serious defects were observed almost immediately in the design of the caterpillars and the mechanism driving them, and also in the method employed for steering the machine. Hence, most of the time and money which had been spent on alterations and improvements to this machine were expended on the caterpillar elements. As a matter of fact the caterpillar difficulties have not yet been eliminated. They could easily be improved or made perfect, but it was not considered necessary to rebuild the caterpillars for the purpose of completing the investigation of this machine, since it was decided, at the close of 1921, to cease operating the Moore plant.

Minor difficulties were also encountered in the excavating element and in other portions of the plant, but these were or could be eliminated without much trouble.

Conclusions Reached at the End of 1920

At the conclusion of the field operations at the beginning of the fall of 1920 a large amount of data was available for comparing the relative merits of the Moore and Anrep plants.

(1) It was clearly demonstrated that the Moore plant showed a marked economy in labour over the Anrep plant, but that in spite of this economy the Moore plant could not compete with the Anrep plant, provided the latter were equipped with an improved delivery and spreading system.

(2) It also appeared from the observations made during the operation of the Moore plant that the maximum length of the bridge work which can be supported by a single caterpillar had been practically reached, and that any extension of this bridge work would make the machine altogether too cumbersome to handle. Twelve rows of peat, therefore, appears to be the maximum number of rows which can be spread with a machine of the Moore type. As stated before,

a linear travel of 56 feet is required in order to lay down one ton of standard peat fuel, and a working face 10,000 feet long for a ten-hour shift, and 20,000 feet long for two ten-hour shifts. If it were possible to lengthen the belt conveyor bridge work to accommodate double the number of rows of peat laid, that is to say, the laying of 24 rows instead of 12, the length of the working face would be cut in two. This would remove certain of the difficulties under which the plant labours, but as stated it does not appear that the length of the belt conveyor can be sufficiently increased without making the entire plant too cumbersome and unwieldy.

(3) The advantage which it was also expected the Moore plant would have over the Anrep plant in harvesting did not materialize. This was due to two causes; (a) when harvesting operations were being carried on as originally intended, a stoppage anywhere along the line from the excavator to dumping into storage meant a stoppage of the entire equipment; (b) variations in the weather could not be provided for, that is, an exceptionally dry spell would permit the drying of the fuel to proceed too far before it could be harvested, and if the weather were abnormally wet, there was the further danger of the whole plant being stopped or held up waiting for the fuel on the ground to dry. On account of these two difficulties, it was decided that it would be more efficient to harvest the production of the Moore plant with the harvesting equipment employed with the Anrep plant—even though this equipment was not designed for operation in connection with the former—than to attempt to harvest with the machine itself as was originally intended.

(4) The quality of the fuel manufactured during the early part of the season compared unfavourably with that produced by the Anrep plant. This was in part due to the inferior quality of peat in that portion of the bog where the Moore plant operated, but it was also partially due to the fact that the long working face, over which the machine takes only one complete cut before a complete row is laid down, is likely to freeze to a considerable depth in a cold winter, and that the first rows which are made from the peat excavated from a frozen face would produce peat of an inferior quality. In the case of the Anrep plant the excavation is made over a very short working face, consequently, it is possible to dig away the frozen face before the operation of making peat is begun. A certain quantity of peat manufactured with the Moore plant during the season of 1920 was of inferior quality due to this cause.

(5) In order to carry out in the most economical manner the various operations in the manufacture of peat fuel according to the air-dried machine peat process, it is necessary that the plant and machinery employed be as simple as possible, since it is not feasible to have skilled workmen on hand to operate a plant which may be situated at some inaccessible point, and which, moreover, can operate for only a part of the year Any peat plant, therefore, which required for its operation skilled labour suffers a severe handicap. The Moore plant to a certain extent is under this handicap, since to operate it to the best advantage more skilful and more careful operation is required than with the Anrep plant. Moreover, the uniformity and quality of the fuel laid down by the former plant depends to a large degree on the care exercised by the operator. This applies to a certain extent also to the Anrep plant, but its operator has a much better control over his machine, and does not therefore require to exercise the same degree of skill.

On account of the above defects which were observed in the operation of the Moore plant and those which were noticed in the spreading system employed with the Aurep plant, the Peat Committee decided to recommend that the best features of both plants be incorporated in a combination plant. The following table gives the principal data obtained during the operation of the Moore plant in 1919, 1920 and 1921.

TABLE I.—OPERATION OF NO. 2 OR MOORE PLANT.

	1919	1920	1921
Total length of working season exclusive of Sundays	....	105 days.	107 days
Total days actual operation	....	(a) 41 days.	62.3 days
Unavoidable lost time	....	18.4 days	12.4 days
Percentage of season	....	17.5	16.6
Avoidable lost time	....	15.6 days	32.3 days
Percentage of season lost through delays which might have been eliminated	....	43.4	30.1
Distance travelled, about	45,000 feet	149,250 feet	242‘250 feet
Fuel laid down	(b) 500–600 tons	(c) 2,665 tons	(d) 3,889.5 tons
Fuel laid down per hour, average	....	3.4 tons	5.2 tons
Total labor cost to operate plant	$1,023 82	(e) $4,603.33	$3,380 27
Total labor cost for repairs	....	$1,138.50	700 77
Labor cost to lay out per ton	....	(f) $1.75	0.869
Cost of cubing per ton	....	(g)	0.20
Total labor cost ready to harvest	....	....	1.07
Total labor cost if troubles eliminated	....	....	0.807
Maximum day production	....	53.6	70 tons

(*a*) Does not include 180 hours night work which is included to arrive at average production per hour in 1920.

(*b*) This distance travelled should have produced 800 tons, but no fuel was made during the first three or four cuts when working face was being opened up.

(*c*) It is estimated that 2,985 tons of fuel were made by No. 2 in 1920 on a basis of 50 lineal feet of row laid out per ton, and harvesting records would seem to confirm this figure, but 1921 records show it requires 56 lineal feet of row to produce one ton of 30 per cent. moisture fuel, and this figure has been used so as to make a fair comparison with 1921. The apparent greater production in 1920 is accounted for by the fact that the fuel harvested was not dried down to 30 per cent. moisture content.
About 1,600 tons of fuel made by No. 2 in 1920 sold for $4.00 per ton.
About 200 tons of fuel made by No. 2 in 1920, was used for fuel.
About 865 tons of fuel made by No. 2 in 1920 was not dry enough to harvest.

(*d*) Estimates of fuel made in 1921 on basis of 56 lineal feet of movement of spreader check very closely with actual weights.

Total fuel weighed into storage	3,194.5 tons
Total fuel used for fuel	221.0 tons
Total fuel wasted on field in harvesting	116.0 tons
Total fuel left on field not dry	358.0 tons
	3,889.5 tons
Known loss in production through thin spreading, about	450.0 tons
Total	4,339.5 tons
Theoretical production for 242,250 feet at 56 feet per ton	4,326.0 tons

(e) This figure includes $735.00 cost of night shift, and $700.00 paid to two additional men over regular shifts who were necessary to look after suction hose through which water was drawn to the boiler. For a fair comparison with 1921 this latter figure should be subtracted from the total, making cost per ton:

(f) $1.47

(g) Cost of turning and cubing in 1920 for the first part of the season was done by day labor. A great deal of work was done on old frozen peat in an attempt to save it, and the total cost for turning and cubing in 1920 is abnormally high, so that any figure given would be misleading. In the latter part of the season cubing was done by contract for 20 cents per ton.

During 1919, No. 2 plant was given a mechanical try-out, and only a small quantity of fuel was manufactured in the course of experimentation. In 1920 an effort was made to operate the plant during a full working season. The total length of the working season, exclusive of Sundays, was 105 days, and the total days during which the machine was actually operated was 41. It will be noted that the total days of actual operation during 1921 were greatly increased, and that the unavoidable lost time was reduced from 18.4 days in 1920 to 12.4 days in 1921, which corresponds to 17.5 and 11.6 per cent. respectively of the entire working season. The avoidable lost time during 1921 was notably decreased from that of 1920, namely, from 43.4 to 30.1 per cent. A very large increase will be noted in the lineal distance travelled by the plant in 1921 as compared with that travelled in 1920, and the average fuel laid down per hour in 1921 is notably greater than that laid down in 1920, namely, 5.2 tons, which is about 8-10ths of a ton less than the maximum which was expected.

It would appear, therefore, from the results of these three seasons that this plant could be brought to a high degree of efficiency, and that most of the mechanical troubles experienced could be entirely eliminated, which would make it possible to lay on the field the requisite quantity of fuel during an entire working season, provided a 10,000, foot working space were available.

It is necessary at this point to direct attention to the fact that no attempt was made to put the machine in perfect condition for operation during the season of 1921, since to do so would involve a large expenditure of money which the Committee could not recommend. This machine, therefore, began operations under a severe handicap which was in no sense decreased as the season advanced.

Regarding the total labour costs to operate the plant in 1921 as compared with 1920, it will be noted that for a greater production of fuel the labour cost is one-third less, and that the cost for repairs is also in the vicinity of one-third less than in 1920, but the decrease in labour cost is more noticeable in the costs calculated per ton of fuel laid down, namely, $0.869 in 1921 while in 1920 it was $1.75. This shows a reduction of approximately 50 per cent. If the troubles above-mentioned were eliminated, the labour costs for laying down a ton of fuel would be reduced to practically 81 cents. In 1921 the maximum daily production realized was 70 tons, while that of 1920 was 53.6 tons. The total quantity of fuel manufactured during 1921 was 3,889 net tons of 2,000 lbs., 450 tons were lost through defective spreading; the total production was consequently 4,439 tons. This checks very closely with the theoretical quantity which should have been produced for a lineal travel of 242,250 feet, namely, 4,326 tons. Table No. 2 gives a summary of the troubles experienced with the machine during the season of 1921, the time lost and the reasons therefor.

TABLE II.—SUMMARY TROUBLE SHEET, PLANT NO. 2, 1921

Cause	Unavoidable		To be expected		Due to known defects which could have been eliminated	
	Hours	Minutes	Hours	Minutes	Hours	Minutes
1. Weather	26	45				
2. Turning					11	55
3. Cross Ditches					3	15
4. Oiling					7	20
5. Move from field to field					20	40
6. Engine			4	0	4	35
7. Excavator element			10	0	14	45
8. Roots in Excavator			1	45		
9. Chains			8	0	52	17
10. Belt			1	10		
11. Spreader			12	0	39	35
12. Cross Cutter			4	5		
13. Ties			0	10		
14. Sprockets			8	20		
15. Clutches			4	0	8	5
16. Gears			1	0		
17. Late starting					0	50
18. No steam					10	30
19. No water					14	33
20. No fuel						40
21. Roots in Macerator			15	0	22	15
22. Iron in Macerator			10	0	31	45
23. Variable Speed			13	0	13	10
24. Loader					25	0
25. Stacker					0	45
26. Harvesting					3	40
27. Repairs			18	20	36	45
	26	45	97	50	322	20
Total	2.675	days	9.78	days	32.23	days

Costs

While this investigation is being conducted for the purpose of developing machinery capable of performing all the operations required to convert the raw peat substance of a bog into a marketable fuel with the greatest degree of efficiency, such efforts would result in nothing but waste in time and money were the cost of the fuel so produced too great to permit competition with other classes of fuel now on the market.

The main objective has, therefore, been to develop machinery which can not only perform the various mechanical operations in the most efficient manner possible, but also produce a fuel at an economic cost. This has not proven to be a simple problem. The removal of one difficulty which barred the road to success often introduced another equally or more serious, and, as often happens in the development and refining of processes and their application commercially, the Peat Committee were confronted with the fact that the refining of mechanical appliances can be carried to a point where the saving resulting from the higher efficiency of labour-saving devices is more than offset by the increased cost. Consequently, the problem with which this investigation is chiefly concerned, resolved itself into the co-ordination of manual labour and mechanical labour-saving devices so that the human element and the mechanical element would be properly balanced.

In order to produce a low grade fuel like peat from a very low grade substance such as raw peat, which contains ninety per cent water and only ten per cent. combustible matter and ash by weight, with machinery capable of performing the various operations to a large degree automatically, the output of finished fuel per unit of time must be as large as possible. This implies a large and powerful manufacturing unit which in itself, introduces a serious difficulty, viz.: overhead costs.

Plant No. 2 was replete with labour-saving devices which partially defeated the very object of their introduction, and its elimination as a machine for manufacturing peat fuel on a commercial generally was partly due to these defects. A detailed estimate of the total cost of one ton of standard peat fuel as manufactured by this machine as it stands would consequently be of little or no value. In the light of the experience gained during two complete seasons' operations, a new machine of the Moore type could be built at a much lower cost than was possible with the original machine, and, moreover, the new machine would have incorporated into its design improvements which would correct many of the defects of the former, and would as a result be far more efficient, and under special conditions, even prove commercial.

With the results and records of operation now at the disposal of the Committee, it is possible to roughly estimate the cost of producing standard peat fuel with plant No. 2—re-designed and rebuilt. However, it must be understood that these costs are subject to revision in the final report when detailed estimates of the costs of a complete plant will be obtained.

The estimated cost of making fuel with the Peat Committee Plant No. 2 is based on the conditions:—

1—Plant rebuilt in light of all knowledge gained.
2—Plant is electric-motor driven.
3—10,000 feet working face available.
4—Minimum wages 35 cents per hour.
5—100 days minimum working season.
6—Ten-hour shift.

and that the capacity of the machine when re-designed and re-built will reach an average of 60 tons of standard peat fuel per day for 100 days. There is no reason to doubt that this and even a greater production would under these circumstances be realized. For convenience the details of the estimates are placed under the following headings:

A.—Capacity of machine.
B.—Production cost.
C.—Overhead.
D.—Costs if plant is driven by self-contained steam plant.
E.—Costs if plant is driven by Semi-Deisel engine.

The subject matter under these heads is sufficiently clear to require no further explanation.

A.—Capacity of Machine

Plant No. 2 moved 242,250 ft. in 1921 in 62.3 days elapsed time, of which four days were spent in shifting to new position.

Therefore, plant No. 2 moved 242,250 feet in 1921 in 58.3 days actual travel or 415.5 feet per hour. But observed speed of travel of machine was over 8 feet per minute, or, 480 feet per hour.

Therefore Plant No. 2 lost 7.75 days during 1921 operation not recorded in trouble sheet. Of this the greatest part was due to holding back when using its own harvester, and from travel records it is estimated this amounted to between 4 and 5 days, and the balance say 3.75 days was lost by short delays which were unrecorded.

There is no reason why an improved No. 2 Plant should not sustain a rate of travel of 8 feet per minute when in motion, equal to 480 feet per hour equivalent to production of 8.5 tons of fuel per hour.

Known unavoidable delays	=	11.6 per cent.		
Unrecorded delays	=	3.6 per cent.		
Delays due to shifting machine to new position on the field (on 10,000 ft.-face)	=	1.8 per cent.		
Total delays	=	17 per cent.		
Therefore capacity of plant should be 83 per cent. of 8.6 tons			=	7.0 tons per hour
or per 100 days			=	7,000 tons
Deduct for fuel		400 tons		
left on ground		210 tons		
waste at loading 5 per cent.		350 tons		
Say				1,000 tons
Net amount available on cars			=	6,000 tons

B.—Production Cost

This covers items which vary as number of tons manufactured.

Cost of raw materials on royalty basis per ton	0.05
Operation:	
Runner per day	$5 00
Man in excavator	3 50
Spreader	3 50
Spare man	5 00
Electrician and Mechanic	7 50
Fireman	4 00
Water boy and messenger	1 50
Total per day	30 00
Allowing 25 days to open up and close down for winter—	
125 days at $30.00 per day—Total labor cost	$3,750 00
or, per ton	0 625
Supplies, oil, etc.	0 015
Turning by contract	0 15
Harvesting to storage or Railway Cars	0 60
Total Production Cost	1 44

C.—Overhead

Estimated capital Investment:—		
No. 2 machine complete with motor drive	$10,000 00	
Harvester for same	1,200 00	
16.-lb. track 12,000 ft.	5,000 00	
12.-lb. track 2,000 ft.	600 00	
Harvester cars (12)	1,500 00	
Locomotive	1,500 00	
Storage and Loading Equipment	3,000 00	
Railway Siding	1,500 00	
Office, machine shop, power house and transmission	15,000 00	
Total Capital Layout	39,300 00	
Add for under-estimate and emergencies 10 per cent.	3,930 00	
Total say	$45,000 00	
Total Production Cost		1 44
For Capital Charge:—		
Write off for all purposes 20 per cent. of $45,000 00	$ 9,000 00	
or per ton for 10-hr. shift		1 50

for 16-hr. shift	95c.	
for 20-hr. shift	75c.	
For Executive overhead charge:—		
Manager for year	$2,400 00	
Clerk 8 mos. at $75 00	600 00	
Office Expenses	600 00	
Total	$3,600 00	
Or per ton on 10-hr. shift		0 60
16-hr. shift	37½c.	
20-hr. shift	30c.	
Add to re-handle from storage to cars		0 35
Total cost for 10-hr. shift		$3 89
16-hr. shift		3 11
20 hr. shift		2 84

D.—Cost if operated by Self-Contained Steam Plant

Raw material		0 05
Production Cost:—		
Fireman	$4 00	
Engineer	7 50	
Runner	4 00	
Man in Excavator	3 50	
Man to get Fuel	3 50	
Man on Spreader	3 50	
Spare man	5 00	
Mechanic Helper	3 50	
Water boy	1 50	
Total	$36 00	
Or for 125 days=$4,500 00; per ton		0 75
Add Supplies		0 015
Turning		0 15
For mechanic if manager and mechanic not same man		0 10
Harvesting		0 60
Total Production Cost		$1 665
Overhead:—		
No. 2 machine complete with steam power	$15,000 00	
Harvester 1	1,200 00	
Track 16-lb.	5,000 00	
Track 12-lb.	600 00	
Cars	1,500 00	
Locomotive	1,500 00	
Storage and Loading Equipment	3,000 00	
Siding	1,500 00	
Office and machine shop	2,500 00	
Total	$31,800 00	
Plus 10 per cent.	3,180 00	
Say	$35,000 00	
Or for 10 hours—overhead charges per ton		1 17
Executive overhead charge		0 60
Re-handling charge		0 35
Total		$3 79

E.—Cost if driven by Semi-Deisel Engine

Raw material		0 05
Production Cost:—		
Engineer	$7 50	
Runner	4 00	
Man in Excavator	3 50	

Man on Spreader	3 50	
Spare man	5 00	
Mechanic	6 00	
Mechanic helper	3 50	
Water boy	1 50	
Total	$34 50	
Or for 125 days—$4,312 50; per ton for 6,400 tons		0 68
Supplies		0 025
Turning		0 15
Harvesting		0 60
Total Production		$1 505
Overhead:—		
Total capital investment not greater than for steam, Or annual charge of $3,600 00 for 6,400 tons; per ton		$1 10
Total executive charge same as for steam, Or annual charge of $3,600 00 for 6,400 tons; per ton		0 56
Re-handling charge		0 35
Oil fuel 1 gal. per H.P. at 11 cents per ton		0 11
Total		$3 625
Summary:—Separate steam-driven power plant		3 99
Self-contained steam-driven power plant		3 79
Self-contained crude oil engine		3 625

Farmers' Plant

Plant No. 3 is in design a miniature Moore-Anrep combination plant. The method of supporting the excavating and macerating element is based on the principle employed with the Anrep system, while the delivery and spreader system employs the principles so successfully demonstrated in the Moore plant. But in order to combine the features of these two plants on a small and economical scale new problems arose which had to be solved. In the course of its development many discouragements were experienced, and it appeared at one time as if the entire design would have to be changed; but an alteration to the excavating-macerating element and a rebalancing of the other parts of the machine, together with the installation of a more powerful motor, eradicated many of the worst difficulties, and a few further changes put the machine into such condition that the Committee see no reason why it cannot be successfully operated during the coming season.

Like the larger machines, this small peat plant must also provide means to excavate, macerate and spread the pulped peat on the ground. In order to carry out these operations in the most simple and economical manner effort was made to design an element which would combine, in one, the operations of excavating and macerating.

As the machine now stands, it is expected that its average hourly capacity will be between 1 and 2 tons of standard peat fuel. This will amount to 10 to 20 tons during a working day of 10 hours. The machine is very simple to operate, and can be easily handled by 1 man and 2 boys.

Macerating

The degree to which maceration can be economically conducted has an exceedingly important bearing on the quality of the fuel produced. It is therefore essential that every effort be made, in attempting the manufacture of peat fuel according to the wet process, to obtain the highest degree of maceration consistent with economy. The results which have been obtained during the past three years have led the Peat Committee to conclude that the Anrep macerator as at present constructed is not entirely satisfactory for operation where a high rate of production is required, since it has been their experience that a large amount of the time which has been lost during a limited season of one hundred days during which it is possible to manufacture peat fuel, has been due to stoppages of the plant through choking or breaking of the macerator with roots and pieces of iron, which now and again find their way into it. To avoid loss of time through such stoppages, the Committee made arrangements with the Jeffrey Manufacturing Company of Montreal to experiment with a swing hammer shredder which they were led to believe might prove successful for macerating peat. This shredder arrived at the plant too late for experimentation, but a few minutes' demonstration run which it was possible to carry out showed that the maceration obtained with this machine was far superior to that possible with the Anrep macerator. This shredder will be tried out early in the spring of 1922, and in case it is found unsatisfactory, two Anrep macerators placed in parallel will be employed. Arrangements for installing them are now under way. This will make it possible to obtain the maximum production of peat fuel during an entire working day, and will avoid stoppages since it is not probable that both macerators will be choked up at the same time. Moreover, while one is being cleaned, the other can be overloaded for a short time thus insuring the delivery of a more or less continuous supply of peat to the belt conveyor.

Loss of Peat Fuel through Fire

On November 8th fire was discovered in the stock pile of fuel which contained a portion of this season's production, a quantity of fuel manufactured last season and several hundred tons of broken frozen peat and fines. The fines were stored in this pile preparatory for shipment as a fertilizer-filler and soil-conditioner. The portion of the stock pile where steam and smoke were seen to issue was immediately opened up, and efforts made to quench the incandescent fuel thus exposed. Towards the evening of this day it appeared to those in charge that the fire had been put out, or at least got under control, since smoke ceased to issue from any part of the pile. But a rising wind soon revived the fire which broke out in other parts of the pile, and though strenuous efforts were made to locate the seat of the fire, this proved impossible since it spread with great rapidity when it reached the good peat fuel where an abundant supply of air was available. The meagre and inadequate equipment available which could be used for fighting a fire proved of little avail, and efforts to cut the pile in two, in an attempt to separate the burning peat from the good peat fuel failed owing to a change in the direction of the wind, which blew the poisonous gases resulting from incomplete combustion upon the workers and necessitated their hasty withdrawal. Consequently it was possible to salvage only a very small quantity of the fuel.

Prior to November 8th the superintendent of operations and the engineer to the Peat Committee, who examined the stock pile on many occasions, had no reason whatever to suspect that the peat was on fire, and moreover, the great rapidity with which it developed appears to indicate that it was of very recent origin.

A thorough investigation failed to reveal the cause. It may have been due to carelessness on the part of a labourer, or to a spark from a locomotive which, lodging in the fines, was covered by freshly dumped peat and slowly ignited the fines at a considerable depth. But the theory that the fire was the result of spontaneous combustion can be given but little credence, since there is no record of a peat fire originating in this manner in European countries, where it is the practice to store great quantities of peat in this manner.

Hereafter the peat will be stored in separate piles. This will permit a fire to be attacked more efficiently—should one ever occur again—and at the same time insure the minimum loss, inasmuch as a fire in one pile would be confined to that pile.

However unfortunate such a loss may be, no blame, in light of the evidence obtained, can be attached to any member of the staff responsible for the conducting of the investigation at Alfred.

The stock pile before burning was over 22 feet high, from 30 feet to 40 feet in width at the top and about 100 feet in width at the bottom. These dimensions will give some idea of the difficulties encountered in the attempt which was made to cut the pile in two.

It is estimated that the loss by fire was:—

Quality.	Quantity	Estimated Value.
1921 Good peat fuel	1,780 tons	$8,500 00
1920 Poor disintegrated fuel	600 "	1,800 00
Screenings	100 "	300 00
Damage to trestle		400 00
Total		$11,000 00

Sale of Manufactured Fuel

The Peat Committee has met with considerable difficulty in disposing of the fuel manufactured to the best advantage. This has been occasioned partly by the nature of the work which the Peat Committee is conducting, namely, an investigation which is concerned more with the development of the machinery for manufacturing peat fuel than with the product itself. Consequently, the quality of the fuel placed on the market has not in certain instances been of the best. In order to dispose of the fuel made during a season in the most economical manner, it has been found impossible to avoid shipping a certain portion of the inferior fuel with the good fuel, and a small quantity of the former has therefore found its way into households, and has given rise to a certain amount of dissatisfaction. While it is necessary to call attention to this fact, it is gratifying to know that the complaints from inferior fuel have been exceedingly few, and that by far the greater portion of the fuel sold since the inauguration of the Peat Committee's investigation, so far as the Committee could ascertain, has given complete satisfaction.

The operation of two experimental machines with the consequent laying out of fuel on two sections of a bog widely separated, made it impracticable to instal harvesting and loading apparatus which would enable these operations to be carried out in the most economical manner. The installation of the proper facilities for efficiently harvesting and handling the fuel manufactured would have involved a comparatively large capital expenditure, which the Peat Committee did not feel warranted in incurring, on account of the temporary character of the work they are conducting. Harvesting operations will be discussed under a separate heading.

The policy of the Peat Committee is to dispose of the fuel manufactured to householders, in order to introduce this fuel for domestic purposes. A considerable portion, however, was sold for heating office buildings and to a certain extent the Government buildings of Ottawa, but care was taken not to permit the fuel, in wholesale lots, to get into private hands.

The selling of the fuel in Ottawa and Ottawa district was put in the hands of a selling agent, who undertook to dispose of the entire output. The agreement which the Peat Committee made with him called for the production of 4,000 tons, but this agreement was broken by both the sales agent and the Peat Committee, first by the former in not accepting the delivery of peat as required, and later in the season by the Committee owing to the fire which destroyed a large portion of this season's output.

The selling and distribution of peat fuel presents certain problems which must be worked out independently. They are, however, all practical problems which can be handled more satisfactorily by business men. Peat sales for 1921 were as follows:—

Raw peat sold in cars	1,160 tons	at $5 00	$5,800 00
Raw peat sold locally	125 "	at 5 00	625 00
Old peat sold in cars	85 " 18 "	at 3 00 at 2 50	300 00
Screenings sold in cars	113 "	at 3 00	339 00
Peat on hand saved from fire and sold for future delivery, estimated	50 "	at 3 75	187 50
Approximate total sales	1,551 "	....	$7,251 50
Less contract in connection with sales in Ottawa and Hull, estimated		$460 00	
Joliette Steel Company		248 75	
Car Screenings to Fuel Testing Station		71 16	759 91
		Net	$6,491 59

Harvesting

The harvesting of the finished peat fuel which comprises the operations of taking the fuel off the ground, loading on small tram cars, transporting these to loading trestle and unloading small cars on storage pile or into freight cars for shipment, has presented many problems, certain of which must be worked out independently. Prior to the war such operations have been largely performed by hand labour, but during and since the war labour conditions have changed very materially. As regards wages, and in order to carry out these operations in the most efficient and economical manner, manual labour must be replaced to the largest extent by mechanical devices. When the Peat Committee undertook this investigation, they were of the opinion that the harvesting of a season's production of fuel would not present any problems of unusual nature, and that the ordinary methods could be employed without increasing unduly the cost of the fuel. As the investigation proceeded, however, it has been discovered that harvesting constitutes one of the most important problems, second only to the manufacture of the fuel itself, and that if this operation is not conducted in the most economical manner possible, the economies realized from the development of peat fuel manufacturing machinery will be more than offset by the cost of the former.

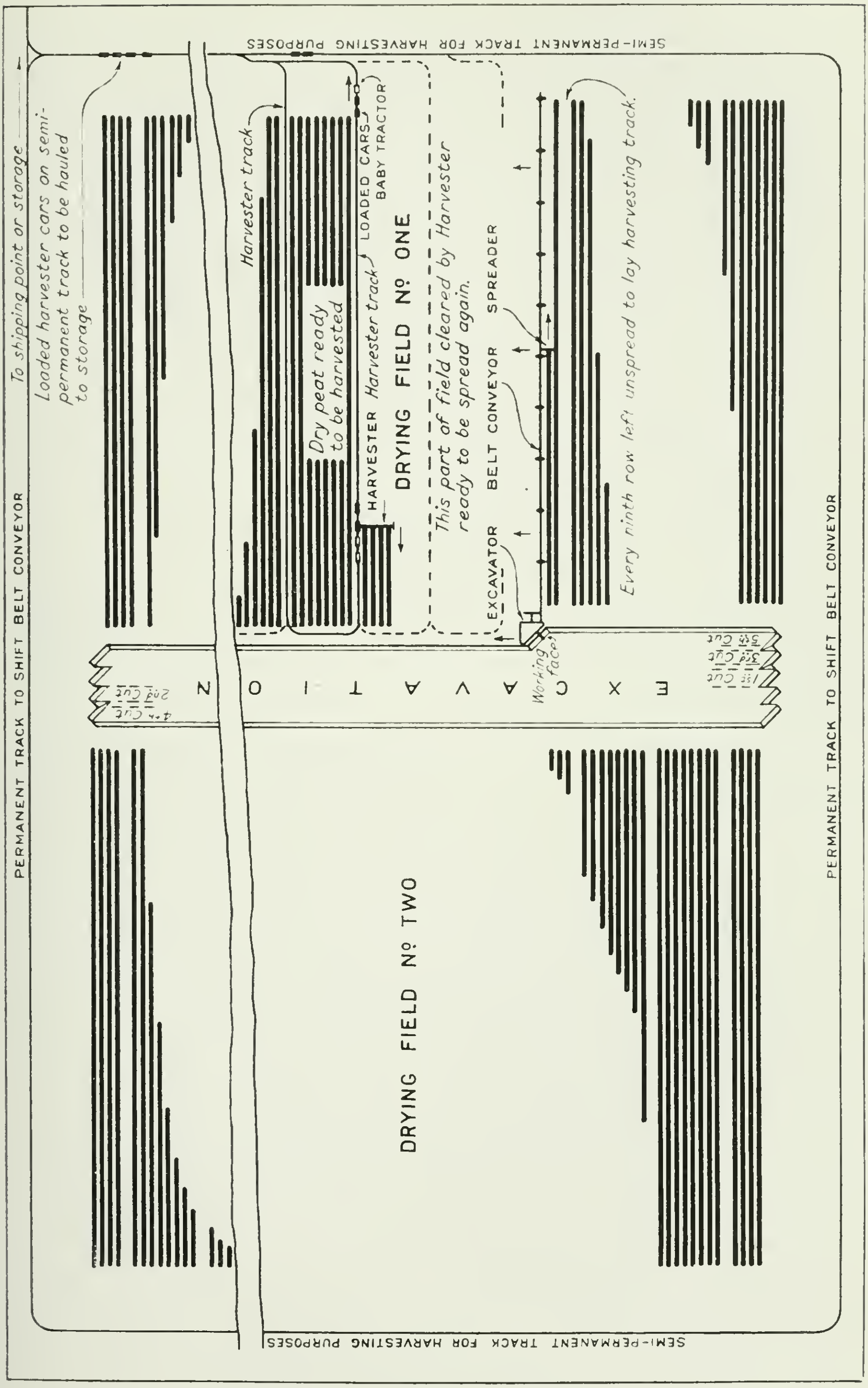
As time permitted, close attention was given to the problems presented in harvesting, and automatic devices were designed, constructed and tried out for certain operations heretofore performed by manual labour. While considerable progress has been made in this direction, the problem is by no means entirely solved, and economies in advance of those so far obtained may be expected. Harvesting a season's production of the No. 4 plant—the combined Moore-Anrep plants—can be performed at a less cost than was the case with plant No. 2, but with the latter plant, little attention was paid to this particular problem, when it was realized that harvesting could not be performed economically by the machine itself. If plant No. 2 had proved satisfactory for commercial operations generally, instead of for special isolated cases, the problem of harvesting a season's production of fuel laid down with that machine would have demanded closer consideration.

The Peat investigation was undertaken at a time when the costs of raw materials entering into the construction of peat machines and general equipment required for the peat manufacturing plant were inordinately high. At this time also labour wages reached the highest level. To-day, these conditions have materially changed: peat manufacturing machinery and other equipment required can be purchased for practically fifty per cent. of the war prices, and labour wages have also dropped materially. The figures of cost which have been prepared for this report are consequently based on higher labour wages than it is expected will obtain during the season of 1922-3.

Meteorological Observations with reference to Drying

Meteorological observations including precipitation, temperature, and barometric pressure, have been made during the season 1920 and 1921. A full record of these observations as well as a complete report on the drying of peat fuel as observed at Alfred will be included in the final report. It will suffice to say here that the observations covering the last two seasons have shown that the maximum period during which peat fuel can be manufactured—that is, laid on the ground and dried sufficiently for shipment—is one hundred working days.

It has been ascertained that peat manufacturing operations can begin as early as the 1st of May and be continued up to the 25th of August.



PERMANENT TRACK TO SHIFT BELT CONVEYOR
To shipping point or storage
Loaded harvester cars on semi-permanent track to be hauled to storage
Harvester track
Dry peat ready to be harvested
Harvester track
HARVESTER
LOADED CARS
BABY TRACTOR
DRYING FIELD Nº ONE
This part of field cleared by Harvester ready to be spread again.
EXCAVATOR
BELT CONVEYOR
SPREADER
Every ninth row left unspread to lay harvesting track.
SEMI-PERMANENT TRACK FOR HARVESTING PURPOSES
Working face
E X C A V A T I O N
1st Cut
3rd Cut
5th Cut
2nd Cut
4th Cut
DRYING FIELD Nº TWO
PERMANENT TRACK TO SHIFT BELT CONVEYOR
SEMI-PERMANENT TRACK FOR HARVESTING PURPOSES

General plan of operation for single unit, Anrep-Moore machine peat manufacturing plant.

Outline of Investigation for 1922

In accordance with the programme submitted in the spring of 1921, the investigation for 1922 will be confined to the operation of the new combination plant and the small plant No. 3 on a commercial scale, the former through an entire working season, and the latter for a sufficient period to demonstrate its value for the work it was designed to perform. The Jeffrey swing hammer shredder which was shipped to the bog last fall too late for experimentation will be thoroughly tested out early this spring, and if the results are satisfactory, it will be employed during the working season for macerating the peat excavated by the combination plant. It is not expected that any new equipment will be purchased, nor will any construction be undertaken with the exception of that involved in the replacing of the loading and storage facilities, which were destroyed by fire. Additional machinery which may be required to carry to completion the investigation will if possible be rented instead of purchased. Arrangements have already been made to rent at a nominal cost an engine for operating the swing hammer shredder, in case it is satisfactory, or the two Anrep macerators in parallel. This engine if purchased would have cost the Committee considerably over $2,000, while on the rental basis it will involve an expenditure of approximately $400 to $500.

Just as soon as the snow is off the ground the new combination plant will be put into condition for beginning commercial operation about the 1st of May. Plant No. 2 will be dismantled, with the exception of the boiler and propelling engine, which it is proposed to employ for supplying the extra power required to operate the new plant.

The harvesting equipment has already been overhauled, so that this is in order for the coming season's work. In order to render the combination plant commercial in every respect an hourly average production of ten tons of saleable peat fuel must be maintained throughout a working season of 100 days. There is no reason to believe, however, that this production will not be realized. An hourly production of ten tons of saleable peat fuel for ten hours a day and for a working season of 100 days means laying on the field a greater quantity than 10,000 tons of finished peat fuel. To accomplish this a longer working face will be required than was necessary for the Anrep plant as it was originally operated, and to provide the additional working face it is planned to operate on both sides of the main excavation according to the plan on page 23. This shows two drying fields, Nos. 1 and 2 . It also shows the semi-permanent tracks which will be laid for harvesting purposes, and the permanent tracks at both ends of the field for shifting the belt conveyor from No. 1 drying field to No. 2.

At the conclusion of the working season in 1922 the preparation of the final report of the operations of the Peat Committee since the inauguration of the investigation in 1918 will be begun immediately.

(APPENDIX)

INTERIM REPORT OF JOINT PEAT COMMITTEE

The original objective which the Joint Peat Committee had in 1918, the year of its appointment, was the testing of peat machines under commercial conditions, in order to determine if a type suitable for manufacturing peat fuel on a commercial basis could be developed. By a process of elimination two types were selected, the well known Anrep peat machine, largely used (in the smaller sizes) in European countries, and the Moore machine. The latter, while not fully developed, appeared to possess so many obvious advantages that the Federal Government, before the appointment of the Peat Committee, decided that it should be given a trial.

On account of the precedence given to war contracts, the two machines were not delivered at the Alfred bog, Ontario, until the spring of 1919, and their erection was only completed in time to enable a short mechanical try-out to be conducted before cold weather set in. It was not, therefore, until the spring and summer of 1920 that manufacturing operations were actually begun.

Up to this time the Committee was under the impression that its work would be completed at the conclusion of 1920 and that sufficient data would be available to enable an opinion to be expressed concerning the commercial possibilities of the two machines. The results of that season's operations, however, disclosed inherent weaknesses in both plants, and the Committee was unable to approve either type for commercial work. Recognizing the great value of a healthy peat development to the Dominion at large, the Committee recommended that a new combination be effected embodying the best features of the two types which had been tried out. This recommendation was approved by the two Governments, Provincial and Federal, and funds were allotted for carrying out the construction and operation of the new combination. The construction was completed late in 1921 and operations were concluded in 1922.

Development of Peat Machinery

The success of any such machine depends largely upon the elimination of manual labour to the greatest extent possible and on the production of a manufacturing unit of large capacity at the lowest possible cost commensurate with good service.

Attempts to meet these two conditions led to the trial of many mechanical devices which heretofore have not been used in this connection. The most noteworthy features involved were the adoption of caterpillar aprons and the substitution of a portable belt conveyor, an automatic spreading machinery for the track system and field presses formerly employed. The development of these and other mechanical features proved difficult and occasioned the expenditure of much time. While the machine has not actually been constructed to the design which the Committee esteems would be reasonably free from defects, the problems involved have, in their opinion, been thoroughly investigated, and drawings for a complete standard equipment with power plant, pulverizing unit, conveyor and spreading system are now under way.

Necessity for Further Government Operation

While the Committee has completed research work requisite to the development of a successful peat manufacturing plant, and is able to place at the disposal of those interested, construction data and operating statistics, it is of opinion that the esablishment of a peat industry is of such importance to Canada and especially the Province of Ontario, that the Governments should undertake the construction and operation of a perfected plant until its possibilities are fully demonstrated.

Cost of Manufacturing Fuel with the Combination Plant

The Committee after careful consideration arbitrarily fixed the price f.o.b. cars peat plant siding, at which peat fuel could in its opinion be sold for consumption, within a 100-mile radius and still compete with anthracite coal. This price was $5.00 per ton of standard peat fuel, containing thirty per cent. moisture, and comprises the following items:—1, production cost; 2, overhead charges; 3, manufacturer's profit.

The production cost depends mainly upon the cost of the raw material, the prevailing price of labour, the number of employees, seasonal variations, and the quantity of saleable fuel produced per unit per working season.

Overhead charges include interest on capital invested, depreciation and administration.

Manufacturer's profit is estimated as it would be arrived at by the investor.

The figures employed in this report are considered fair by the Committee, but those who desire to engage in such an enterprise would naturally estimate their own overhead charges and profit.

In order to keep items 1 and 2 sufficiently low to enable fair manufacturer's profit to be realized and still bring the selling price of peat f.o.b. cars within the limit of $5.00, it was estimated that the minimum capacity of a unit must be 10,000 short tons of saleable, standard peat fuel for a working season of one hundred days. This type of machine should be capable of producing a sufficiently high hourly average of peat fuel throughout an entire season, irrespective of seasonal variations and delays due to breakdowns or other causes, to enable the 10,000 ton figure to be realized. This we believe could be accomplished by constructing the complete unit sufficiently large to produce a maximum capacity considerably in excess of the minimum required.

The improved plant, exclusive of harvesting equipment, consists of four components. 1.–Excavating. 2.–Macerating. 3.–Distributing and spreading. 4.–Power.

The excavating element proved of sufficient capacity to meet all requirements, and the distributing and spreading system was sufficient to deliver and spread the maximum quantity of peat excavated. The macerating element, however, failed to deliver the required quantity with the power available. This was due to the adoption of a new type of macerator, a "Swing Hammer Pulverizer," which it was considerered would prove far more reliable, cheaper and more efficient than the Anrep macerator heretofore employed. This machine had not before been employed for macerating peat and, therefore, its capacity and the power required to operate it for such purpose were not known. A portion of the operating season had to be devoted to experimentation with and calibration of this unit.

On account of the lateness of the season, and lack of funds, the Committee could not possibly consider the purchase of a power plant sufficient to operate the combined plant to full capacity. The power plant used was improvised, comprising two boilers already on the bog, the wasteful steam engines which formed part of the two plants previously experimented with, and a high speed engine which was rented for a season. The two boilers were rated at eighty horsepower each and the engineer of the Committee had reason to believe that practically 160 horsepower would be available. A test, however, disclosed that only 110 horsepower could be developed, while the minimum required to operate the full capacity was estimated to be 150 horsepower. With 150 horsepower and a larger macerator, the full capacity of the plant could have been delivered. Since both these elements are standard equipment and can be obtained in various sizes on the market, the ultimate capacity of the plant can readily be obtained by simply substituting a macerator and power plant of greater capacity.

Costs

Based on the performance of the experimental combination plant and the estimated cost of an entirely new and remodelled plant, complete with an efficient power unit and larger macerator, the production costs and overhead charges of the unfinished peat per ton are estimated to be $2.00 and $2.48 respectively for a 10-hour day or $2.00 and $1.50 for a 20-hour day; or a total cost of finished peat fuel, on board cars at siding of plant of $4.48 for a ten-hour day for a season of 100 days, or $3.50 for a twenty-hour day or a total cost of finished peat fuel, on board cars at siding of plant of $4.48 for a ten-hour day for a season of 100 days, or $3.50 for a twenty-hour day during the same season. A total production of saleable fuel in the first case is 10,000 short tons and in the second, 20,000 short tons. Since, however, the overhead costs mount rapidly as the production decreases, the Committee recommend that plants of this type should be operated for twenty hours per day. The necessity for increasing the length of the working season by operating twenty hours per day will be readily appreciated, when it is realized that the considerable investment represented in plant is, under the most favourable conditions, lying idle practically two-thirds of the year. Thus the overhead would be distributed over the production of only one-third of a year, thus greatly increasing the cost. Working two shifts is equivalent to operating ten hours a day for 200 days. Night operation with this combined plant is entirely feasible: it was not the case with either of the others.

The foregoing costs are below that arbitrarily set by the Committee, as the maximum price at which peat could be sold f.o.b. plant and still compete with coal for domestic purposes. The most notable feature is the marked reduction in the total cost due to reduction in overhead, by operating for a season of two thousand hours instead of one thousand.

The important reductions in the final total cost will be attained by many improvements permitting of substantial saving in the construction of a new plant, and by the employment of a self-contained Diesel engine electric power plant. By using Diesel engines and electric generators and operating all drives on plant with electric motors, it is estimated that a saving of eighty-five cents per ton of saleable peat fuel will be realized, over that possible with the inefficient outfit employed this season. These figures assume the employment of this or some other equally efficient power plant. For a plant producing ten thousand tons, in 1,000 hours, a power equipment of 200 horsepower will be required. The following table recites the estimated costs of building an entirely new plant with power, harvesting, loading equipment, and other accessories. Overhead and administration charges are also shown.

Table of New Plant Costs

Capital Costs	Interest	Depreciation		Administration
		Per Cent	$	
Power plant $25,000.00	7 per cent	10	2,500.00	10 per cent on $100,000.00 for 20 hrs. or 10 per cent on $50,000 00 for 10 hrs. daily operation
Peat plant $35,000.00		20	7,000.00	
Harvesting Equipment $25,000.00		14	3,500.00	
Buildings, Equipment and Miscellaneous $5,000 00		10	500.00	
Total $90,000.00	$6,300.00		13,500.00	$10,000.00 or $5,000.00

Market

A good market has been developed for peat within the economical shipping radius of the Alfred bog. The demand is growing. The success of such a plant depends in a marked measure, however, upon the site chosen for manufacturing in its relation to points of consumption. This should be selected with a view to eliminating long rail hauls. The economic limit depends not only upon freight rates, but on the price of other available competitive fuel. For example, the cost of anthracite to consumers has an effect upon the price at which peat fuel can be sold at the same point. It is the opinion of the Committee, that the price of peat fuel delivered to consumers should be in the neighborhood of $10.00 per ton if the bogs are strategically situated with respect to transportation facilities and within 100 miles of the market.

Plant No. 3, Small Peat Plant

When Plant No. 3, the small plant, was first designed an attempt was made to combine the excavating and macerating units in a single machine, simple in design and inexpensive. Until the end of the season of 1921 efforts were made to perfect the original design, but the results were not satisfactory. Difficulties with the combined excavator and macerator were not completely overcome and it was decided that other means of macerating must be found before this type of machine could be deemed practical from a commercial standpoint. About this time the possibilities of the Swing Hammer Pulverizer were brought to the notice of the Committee and nothing further was done with No. 3, until this machine had been tried out.

The "Swing Hammer Pulverizer" proved to be so superior to the type of macerator formerly used that it was decided to include it in the rebuilding of No. 3. This was carried out during the 1922 season. Construction, however, was only complete after the normal working season and, therefore, no sustained demonstration was possible. The troubles which developed in the first design were overcome. The capacity of No. 3 plant should be not less than one and one-half tons standard fuel per hour, and in regular operation might exceed this. The cost of construction cannot be given at this time as new drawings have to be prepared. It is, however, expected that it will not exceed $5,000.00. A full description of the redesigned machine with a discussion of its capabilities, and accurate figures of its cost, will be given in the final report of the Committee. Three men should be sufficient to operate it.

(Signed.)
B. F. Haanel, *Secretary.*
Arthur A. Cole, *Chairman.* *Peat Committee.*
R. C. Harris.

Toronto, December 5th, 1922.

INDEX VOL. XXXI, PART IV

PAGE
Alfred station 2
Anrep plant. *See* Plant No. 1 .
Anrep macerator 19
Anrep-Moore plant. See Plant No. 4 ....
Belt conveyor (Plant No. 2).
  And spreader (photo) 8
Belt conveyor. (Plant No. 4)
  Described 2-4
  In place for operation (photo) 3
  Another view, excavator in distance 5
Costs.
  Cubing 12, 13
  General 14
  Labour (q. v.)
  Jeffrey swing hammer shredder: purchase of engine to operate as against rental 24
  Labour: Plant No. 2 ....12, 13, 16-18
  Overhead 16
  Reduction in 22
  Plant No. 2:
    capacity of machine 15, 16
    if driven by semi-Diesil engine 17
    if operated by self-contained steam plant 17
    production 12, 13, 16
  Interim report of Peat Committee on 27, 28
Cubing costs. (Plant No. 2) 12, 13
Distance travelled, Plant No. 2 .. 12, 13
Drying.
  Meteorological observations with reference to 22
  Moisture content 4
Farmers' Peat machine. *See* Plant No. 3.
Fire
  Loss of peat fuel through 19, 20
Fuel laid down 12, 13
Harvesting 10, 21, 22
Interim report of Joint Peat Committee 25-28
Investigation for 1922, outline of 22-24
Jeffrey Manufacturing Company of Montreal 19
Joliette Steel Company 21
Labour costs.
  Plant No. 2 ....12, 13, 16-18
  Reduction in 22
Lost time 12, 13
Macerating 18, 19
Machinery and equipment.
  Reduction in costs 22
  Development of 25
Market 28
Meteorological observations *re* drying 22

PAGE
Minister of Mines (Federal Government) 5
Moisture content of Peat.
  Drying down 4
Moore, E. V. 5
Moore plant. *See* Plant No. 2.
Operations during 1921, improved plant. *See* Plant No. 4.
Operations, table of and costs 12
Ottawa and vicinity.
  Peat sales in 21
Overhead costs 16
Peat Committee.
  Findings of 1, 2, 25-28
  Refs. 5, 19, 20, 21
Percentage. (Plant No. 2).
  Lost time, unavoidable and avoidable 12, 13
Plant No. 1 (Anrep plant).
  Fuel Committee's findings on .. 1
  Relative merits of, and Plant No. 2 (Moore Plant) 10, 11
Plant No. 2 (Moore plant).
  Advantages claimed for 5
  Belt conveyor and spreader 8
  Conclusion reached at end of 1920 ....10, 11
  Defects and drawbacks of 6, 10
  Difficulties encountered and improvements made 10
  Distance travelled 9, 15
  Drying field required for season's output 9
  Erection of plant on bog 6
  Harvesting 10
  In operation (photo) 8
  Novel features of 7
  One of the eleven caterpillar elements (photo) 6
  Operation and costs (table) 12, 13
  Peat fuel laid on field by (photo) 7
  Relative merits of, and Plant No. 1 (Anrep plant) 10, 11
  Speed of travel 15, 16
  Spreader: near view of, also cutting device 9
  Time lost 15, 16
  To be dismantled 24
  Trouble sheet (summary) 14
Plant No. 3 (Farmer's plant).
  Description, capacity, and labour 18, 23
  Ref. 2
Plant No. 4 (Anrep-Moore machine).
  Assembling and installation ... 2
  Belt conveyor system, excavator in distance (photo) 5

PAGE

Plant No. 4 (Anrep-Moore machine)—*continued.*
  Belt conveyor in place for operation (photo) ... 3
    another view ... 5
  Belt conveyor (portable) ... 2-4
  Costs ... 26-28
  Drying down ... 4
  General plan of operation for single unit ... 23
  Harvesting by ... 22
  Proposed operations of ... 22-24
  Ref. ... 12
  Spreader attached to belt conveyor (photo) ... 4

PAGE

Production (Plant No. 2) ... 12, 13
Sale of manufactured peat ... 20, 21
Spreader (Plant No. 2).
  Attached to belt conveyor (photo) ... 4
  Belt conveyor and (photo) ... 8
  Near view of; also cutting device ... 9
Storage of peat ... 20
Swing hammer shredder ... 19, 24
"Swing hammer pulverizer" ... 28
Trouble sheet, Plant No. 2 ... 14
  Wages. *See* Labour costs.
Working season ... 12, 13
  Economy of working two shifts 27

PROVINCE OF ONTARIO
DEPARTMENT OF MINES

Hon. H. Mills, Minister of Mines — Thos. W. Gibson, Deputy Minister

THIRTY-FIRST ANNUAL REPORT

OF THE

ONTARIO DEPARTMENT OF MINES

BEING

VOL. XXXI, PART V, 1922

Natural Gas in 1921 = = 1—71
Petroleum in 1921 = = 72—76

By R. B. Harkness

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY OF ONTARIO

TORONTO
Printed by CLARKSON W. JAMES, Printer to the King's Most Excellent Majesty
1923

Printed by
THE RYERSON PRESS

CONTENTS

Vol. XXXI, Part V

Page
Letter of Transmission iv

NATURAL GAS IN 1921

General Conditions 1
Work of the Year 2
Orders issued 3
Percentage contract 3
Measurement of gas 4
Economy in using gas 5
New appliances for burning gas 7
Residue supply 7
Peak loads and their effects 8
Peak loads in cities and towns 13
Leakage 14
Improvements in the fields 15
Production 15
  Table I—Consumption in towns and cities 17
  Table II—Consumption in townships 18
  Table III—Classification by industries 20
Ratio of price to gas consumed 22
Operators licensed to produce natural gas, 1921 23
Operators licensed to drill or bore for natural gas, 1921 24
Operators licensed to operate natural gas pipe lines, 1921 24
Page
Operators licensed to distribute natural gas, 1921 25
Operators licensed to lease and prospect for natural gas, 1921 26
Field operations in 1921 26
  Table IV—Natural gas well drilled, 1921 27
Samuel S. Wyer's report 28
  Part 1.—Present natural gas situation 29
  Part 2.—How to keep natural gas industry alive 32
A new bailing machine 34
Gas wells in Lake Erie 36
General 37
Locating gas leak with match 37
Drillers' logs 38

PETROLEUM IN 1921

Table I—Crude petroleum production in 1921 72
Table II—Crude petroleum production by fields, 1917-1921 73
Drilling operations 73
Exploratory drilling 74
Shooting an oil well 75
Map of oil fields 75
Refining operations 76

ILLUSTRATIONS

Page
A battery of three orifice meters and a fourth auxiliary meter at Windsor 4
Dust trap for removing iron sulphate from natural gas 15
Bailing machine 35
One of the gas wells in Lake Erie near Port Alma, Tilbury East 37
The result of searching for a gas leak with a match or lamp 38
Modern (standard) drilling rig 74
The right way and wrong way of shooting an oil well 75

DIAGRAMS, CHARTS AND MAP

Page
Fig. 1—Diagram showing improper and proper distances between gas burner and bottom of cooking vessel 5
Fig. 2—Temporary methods of shortening distance between burners and cooking utensils 6
Fig. 3—Kent gas field showing past and projected future decline of volume and pressure 8
Differential pressure or rate of flow diagrams 9-12
Pressure and temperature charts, Sarnia, Windsor and Chatham ....*facing* 13
Past and estimated future rock pressure decline of Kent natural gas field 31
Diagram showing tubing holder for renewing leaky tubing in low pressure gas wells 35
Key map of Southwestern Ontario showing location and extent of Oil Fields, past and present, scale 5 miles to the inch ....*facing* 75

Letter of Transmission

Honourable H. Mills,

Minister of Mines.

Sir,—I have the honour to submit my report on Natural Gas and Petroleum for the year 1921. The full calendar year is covered in this report although the writer was not appointed until the passing of the Natural Gas Conservation Act on May 4th, 1921. Mr. E. S. Estlin, who resigned at that time, left sufficient information to discuss the first four months' operations in a general way, but the problems leading up to the passing of the Natural Gas Conservation Act, 1921, have necessarily been omitted.

The small number of complaints from the public and the improved conditions, both in production and distribution, as regards natural gas, indicate that the objects aimed at in the Act have been measurably achieved.

I have the honour to be, Sir,

Your obedient servant,

R. B. Harkness.

Commissioner of Natural Gas.

Office of the Commissioner of Natural Gas,
Toronto, 1922.

NATURAL GAS IN 1921

By

R. B. Harkness, Natural Gas Commissioner

General Conditions

The winter of 1920-1921 was unusually mild. There were only ten days in December and ten in January during which the temperature remained below freezing point for twenty-four hours; and only once in the whole winter did the thermometer register a drop below five degrees above zero.

The shortage of gas noted in previous reports had been taken as a warning, and consumers were advised by circular to put in a supply of coal, since a similar shortage could be expected for the coming winter. Manufacturers were denied the use of gas wherever possible, and restriction orders were issued for gas used for heating schools and public buildings. In some cases manufacturers and gas companies refused to acknowledge the authority of the Commissioner to issue such orders. There is no doubt that the acute shortage experienced during the winter of 1920-21 was directly due to the large quantities of gas used in industries and for heating large buildings. Wasteful appliances and leakage also contributed to the shortage as in past years, though conditions in these respects were improved as compared with the previous year. Windsor and Sarnia suffered more than Chatham, being farther from the field.

The Natural Gas Conservation Act, 1921, became law on May 4th, and contained a provision authorizing the varying of contracts in the interest of gas conservation for domestic use. Industries were at once instructed to change their equipment so as to use some other fuel wherever possible. These directions were generally obeyed; in some cases where they were not taken seriously, inconvenience was felt when the change had to be made later on short notice. Many manufacturers spent a great deal of money experimenting with other fuels, and a few were unable to find any other suitable for their needs. In these cases gas was allowed if only a small quantity was required. Some industries were permitted to use gas on giving up an equal quantity previously used for domestic purposes. In nearly every case the mayor and council of the town or city was consulted before depriving any industry of natural gas, when such action would probably lead to throwing men out of employment. Two large cities recommended that no industry whatever should be permitted to use gas, and most of the remainder recommended that only a selected list should receive such permission. Table No. III, page 20, shows how gas was distributed among industrial concerns. These measures had a marked effect at once, as will be seen on a study of the insert charts. These charts compare the gas pressure in the Tilbury field during the months of November and December, 1920, with the same months in 1921, and also the pressure for these months at the point where the Union Natural Gas Company delivers gas to the Windsor Gas Company for distribution in Windsor. A glance will show the great improvement in pressure at the Windsor end of the line, and it will be seen that whereas in November 1920, the pressure went below ten pounds on twenty-three days, in November 1921 it went below that point only on five days. In December 1920, pressure was below ten pounds on twenty-eight days, while in December 1921, only on eleven days, and in November and December 1921, the weather was, if anything, colder than in the same months of 1920. Similar graphs are given for Sarnia and Chatham, which show like results in a less marked degree, owing to their smaller population.

A remarkable feature is that the average pressure in the gas field was at least ten pounds greater in 1920 than in 1921, and at Windsor thirty pounds lower in 1920 than in 1921: indicating a greater demand in Windsor in 1920; which is borne out by the fact that the sales of gas in November and December, 1920, were twelve per cent. greater than in the same months in 1921. Again, on examining the Windsor low pressure chart on page 9, it will be noted that on Christmas Day 1920, the pressure at the consumer's gas range was as low as one-quarter of an ounce at one p.m., whereas on Christmas Day, 1921, it was slightly below one ounce at the same hour, and for nine hours averaged nearly four ounces higher than on Christmas Day, 1920, outside temperature being practically the same in both cases. While many complaints were received from citizens of Windsor in 1920, none were received in 1921; the reason being that the people used less gas but used it more carefully, thus enabling the gas company to maintain a higher pressure for the benefit of all. Undoubtedly the higher rate charged for gas in 1921 had also a material effect, but an examination of the graph shows that after each meal the pressure at the city limits increased slightly. As industries were not using gas to any great extent in 1921, this can only be interpreted as indicating that the lessened demand after the meal-time "peak load" allowed the pressure to build up for a time, and thereby improved the service.

Work of the Year

The winter months from January until March were fully taken up in distributing the inadequate supply of gas among consumers and industries, making inspections and investigating complaints. A survey of the Kent gas field was made by Samuel S. Wyer, natural gas expert and consulting engineer of Columbus, Ohio, and a report was submitted by him on May 29th, 1921. A copy of this report which is given on page 29 was sent to every one of the municipalities using natural gas in Ontario.

On June 1st, 1921, the Natural Gas Commissioner's office was moved from Chatham to 5 Queen's Park, Toronto.

The supplying of gas to the village of Fonthill and Pelham township, undertaken by Commissioner Estlin in October, 1920, the Relief Gas Company having become insolvent and unable to continue in business, was turned over to a committee representing these places on July 1, 1921. The pipe line and distributing plant of the Relief Company was subsequently sold, and Fonthill and Pelham are now being supplied with gas by the purchaser, R. G. Kerlin, of Hamilton.

During the month of August and at intervals in October and November the gas fields were inspected, and an attempt made to mark on the map the location of all wells drilled and all pipe lines in Ontario, also the owner of each. This was a heavy task, but much was done; most of the fields were inspected and many wells located on the map. This hasty inspection brought out the fact that some companies and most private well owners neglected their wells and allowed them to fill up with water. The correction of this condition had to be left over until 1922.

All hearings to adjust rates held by Geo. F. Henderson, Referee under the Natural Gas Conservation Act, 1921, were attended as follows:—

Chatham, July 11-14, 1921, application by Union Natural Gas Company; ditto Sept. 29 1921.

St. Thomas, November 23, 1921, application by Southern Ontario Gas Co.; ditto, December 8, 1921.

Aylmer, November 22, 1921, application by Central Pipe Line Co.; ditto, December 7, 1921.

Welland, October 5, 1921, application by Provincial Gas and Fuel Co.

At these hearings rates were fixed for most municipalities in Western Ontario.

Inquiries of an official and semi-official nature were held at Belmont, St. Catharines, London, Welland, Stevensville and Ridgeway.

Orders Issued

The following Orders were issued:—

Order No. 17: limiting the amount of leakage allowable on all pipes; providing for metering or measuring of all gas and for the inspection of consumers' appliances.

Order No. 18: prohibiting the use of gas without charge, and providing for compensation.

Order No. 19: imposing certain restrictions with regard to heating in public buildings, schools and churches.

Order No. 20: amending Order No. 18.

Most of the industrial plants using gas were inspected during the year, and when it was found that natural gas was being used where other fuel could easily be substituted, or could be used to better advantage, permission to use natural gas was withdrawn.

In the month of November the industrial gas situation in Chatham, Windsor and Sarnia was given special attention. The representatives of the industries and the mayors of these cities were met, conditions were very frankly discussed, and all assisted in finding a solution.

The remainder of the year was employed in various inspections in gas fields and distributing plants throughout the Province.

B. D. Burn, Inspector, has carried out his many duties most satisfactorily, these ranging from testing and adjusting gas stoves to plugging gas wells.

Percentage Contracts

It was recommended by Mr. Wyer (see report) that all percentage contracts should be abrogated at once. Consequently, on July 8th the Commissioner met the companies who paid for the gas they distributed on a percentage basis, and asked them to show cause why they should not pay for their gas at the point of junction of the high pressure mains with the distributing plant, so that the excessive leakage should be reduced to an attainable standard of 200 M cu. ft. per mile of three-inch pipe. The distributing companies all agreed to so improve their plants that the leakage would be kept at least up to this standard. They were given until July 1st, 1922, to make the necessary improvements and repairs.

Measurement of Gas

Large volume and high pressure orifice meters are in general use, and are indispensable to the natural gas industry. These meters give general satisfaction, and vary within the same small limits as the domestic meters commonly used in dwelling houses for measuring retailed gas. The meters installed in 1921, in compliance with Order No. 17, were as follows:—

ORIFICE METERS.

City of Windsor	3
Blenheim	1
Dresden	1
Tilbury gas field	5
Dover do.	1
Kingsville	1
Dundas	1
Total	13

A battery of three orifice meters and a fourth auxiliary meter at Windsor.

In addition, 54 positive meters were placed where short lines leave the high pressure mains. These meters check the quantity of gas entering the short lines against the quantity delivered to the consumers served therefrom. This work was begun in July, when the gas companies were assured of higher rates for their product, and was continued until the end of the year, some work remaining to be completed in 1922. Companies with very scattered gas wells and short pipe lines have been exempted from this requirement. All gas is measured in this way from the wells to the high pressure pipe line, from the high pressure pipe line to the distributing plant, and from the distributing plant to the consumer. All these measurements are reported monthly on a form supplied by the Department. The leakage reported is noted, and steps taken to curtail anything that seems to be excessive.

The result of this measure of control has been a marked decrease in the leakage of most distributing plants. The Wallaceburg Gas Company laid several miles of new pipe, and reduced its leakage from 4,900 cu. ft. per mile of three-inch pipe per annum to 2,969 cu. ft. By reason of the fact that gas companies read meters every day in the month, any one month's figures will also include some gas used in the previous month: consequently it will require one year to obtain definite information as to the total reduction of this waste by leakage. Another result of the campaign against leakage is that it has been found that the pressures carried on distributing systems are higher than necessary, and on several plants the pressures are being lowered. The largest cities now using natural gas are being supplied at two to four ounces, but there is still much room for the reduction of pressures generally.

Economy in using Gas

An effort has been begun to teach the general public how to use gas more economically. The gas companies were directed (Order No. 17) to inspect and adjust appliances, recommend changes in the same where necessary, and generally explain how economies could be effected. A set of directions showing in detail and by means of cuts how to arrange burners so as to obtain the best service when the pressure drops, was sent by the Department to every consumer of natural gas, These directions originated in Ohio State University, Columbus, Ohio, and are reproduced below.

In burning gas for cooking three distinct steps are necessary:

(a) The gas must be properly burned; that is, it must be properly mixed with air so as to burn with a pale blue non-luminous flame. A luminous flame will be wasteful and will deposit soot on the cooking vessel.

(b) The flame must be properly directed, that is, the tip of the flame must come close to the cooking vessel. If the flame is too short to reach the cooking vessel, or is blown to one side by a strong draft of air, gas will be wasted, a longer time will be required, and if the flame tip is too far away it may be impossible to cook, although the short improperly directed flames may be kept burning a long time.

(c) The heat generated by the burning gas must be delivered through the cooking vessel walls and into the food. Hence, thin vessels and grid or open stove tops are necessary for good service. Natural gas should never be used under a solid stove top because it is always wasteful and under low pressure conditions may make cooking impossible.

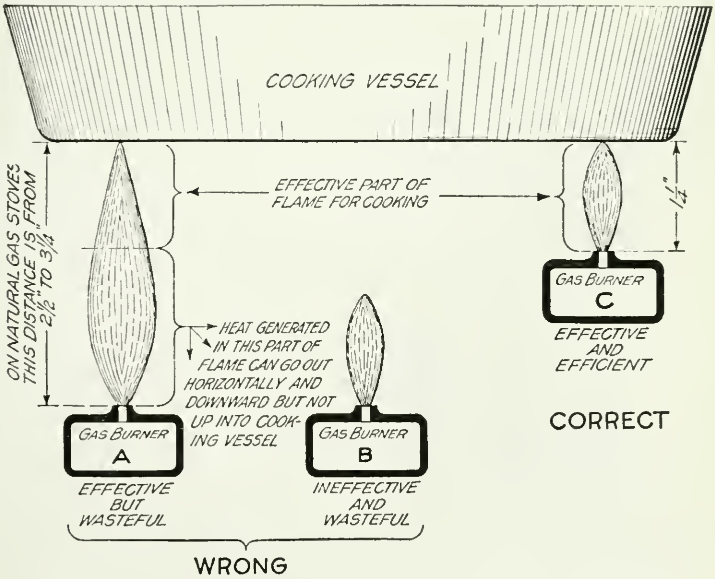

COOKING VESSEL
ON NATURAL GAS STOVES THIS DISTANCE IS FROM 2½" TO 3¼"
EFFECTIVE PART OF FLAME FOR COOKING
1¼"
HEAT GENERATED IN THIS PART OF FLAME CAN GO OUT HORIZONTALLY AND DOWNWARD BUT NOT UP INTO COOKING VESSEL
GAS BURNER A
EFFECTIVE BUT WASTEFUL
GAS BURNER B
INEFFECTIVE AND WASTEFUL
WRONG
GAS BURNER C
EFFECTIVE AND EFFICIENT
CORRECT

Fig. 1.—Diagram showing improper and proper distances between gas burner and bottom of cooking vessel.

A and B in the illustration (Fig. 1) show what happens when low pressure natural gas is burned in the usual natural gas stove. Position B shows cooking vessel so far away that the short flames cannot reach it, resulting in waste of gas, longer time to cook, and in some cases impossibility to cook at all, even though the gas may be burned for a long time. In A, two-thirds of the flame does not reach the bottom of the vessel, i.e., this gas is wasted.

Merely lowering the cooking vessel or raising the burner, as shown at C in Fig. 1, will result in satisfactory cooking, in the usual length of time with same low pressure, same stove and same burner. In fact, properly directed short flames at low pressure, as shown at C, will actually use less than one-half of the gas required with the usual high pressure and resulting long flames.

Correct Position of Burner and Vessel.

For permanent service in purchasing new stoves, get either an artificial gas stove or a natural gas stove with burners properly raised for short flame service. Old stoves worth remodeling may be changed by:

(a) Raising the burner, burner supports, and manifold—that is, pipe into which gas burner cocks are screwed.

(b) New burner castings of proper height for short flames may be secured for some stoves.

(c) Cementing casting on top of existing burners so as to bring the burner top to the proper height.

(d) Depressed grid tops to bring the vessel support down to the low burners.

Closed tops should never be used and in all cases where burners are raised, grid or open tops must be used with the short flames.

A larger sized spud opening—that is, the small opening immediately in front of the gas cock through which the gas passes into the mixer—should be used with low pressure service. Some stoves have adjustable spuds; others must either have new spuds or have the old small openings reamed larger.

If the pressure in the gas mains is too high, the more efficient short flame low pressure conditions can still be maintained by merely partially opening the gas cock. Never let the flame lick up along the side of the vessel.

Baker burners need not be raised, because the heat from the burning gas is already inside of the chamber to be heated. The spud and mixer must, however, be properly adjusted so as to get a pale blue non-luminous flame.

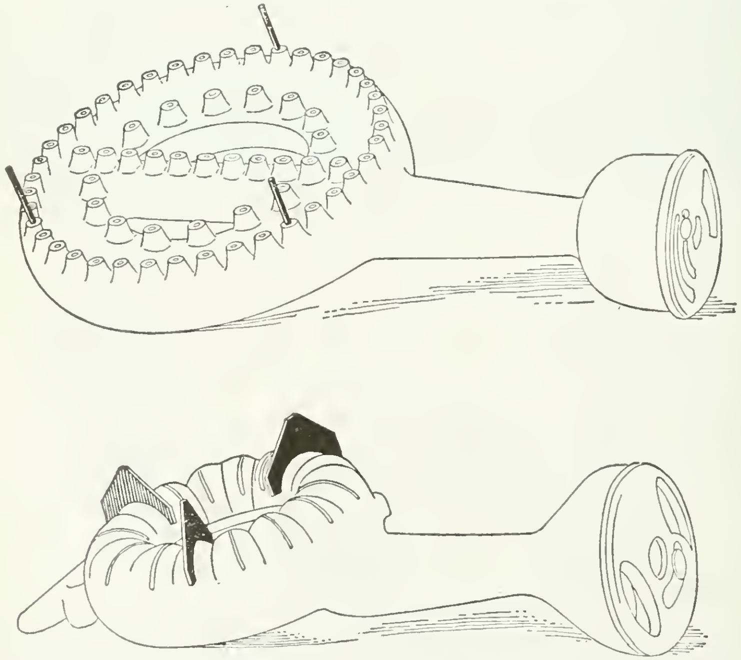


Fig. 2.—Temporary methods of shortening distance between burners and cooking utensils.

As a temporary means, remove the stove top and on drilled burners insert three wire nails and on slotted burners, three pieces of sheet iron, for supporting the cooking vessel as shown above, so that the tip of the short low pressure flame comes close to the vessel bottom.

After the boiling point is reached, much gas can be saved by turning down the flame.

Dirty gas burners always prevent proper cooking operations.

New appliances for burning Gas

At the suggestion of two of the gas companies a large stove manufacturing firm has designed and placed on the market a stove specially suited for burning "sulphur" gas, or in fact any kind of gas, with greater economy. A demonstration of the qualities of this stove was given at Windsor and the appliance pronounced a decided success. When it is considered that a large majority of the appliances used for burning gas are old coal and wood stoves converted into gas burners, the advantage and saving that may be derived from a specially designed apparatus can readily be seen. For example, a test made on an old coal stove showed it to consume five cu. ft. as against one cu. ft. in a gas stove with an open top. This means that the old stove is depriving four families of gas, also that one-fifth of the bill is for gas used in cooking, and four-fifths for gas wasted. Of course, with "sulphur" gas, an open top stove cannot be used. It will be interesting to note what the saving effected by the new stove will be. Undoubtedly, some of the heat must go up the chimney, but if the housewife is careful to turn out the gas when she removes the vessel, and to turn the gas down or use a "simmerer" when the water begins to boil, (for water cannot be raised above 212 degrees Fahr. no matter how hard the kettle boils) she would at once notice a difference in the gas bills. The matter of raising the burners to 1¼ to 1½ inches below the bottom of the vessel has been so often urged that it needs no further discussion. An experiment carried out at Ohio State University showed that the average cook wasted eighty-five per cent of the heat in any ordinary gas stove. Surely it is time that the general public seriously studied how to use the remaining supply of natural gas to the best advantage.

Residue Supply

The quantity of gas in any gas field is easily calculated, provided the original rock pressure, present rock pressure, and the total volume of the gas that has been drawn or has escaped from the wells are known. Naturally the records must be carefully kept or the result will fall short of accuracy.

In the Kent gas field a fair record of rock pressures has been kept for a number of years, and computations have from time to time been made. The total volume of gas originally in the field was 190,000,000,000 cu. ft. This and the quantities used each year are shown in graphic form, Figure 3. Although theoretically the decline in rock pressure and the decline in volume should follow the same line, it is practically impossible to record either with sufficient accuracy to make them identical. However, the result is on the whole satisfactory.

The projected future supply is taken from Mr. Wyer's report, where it was shown in terms of rock pressure. By noting on the chart the quantity of gas that may be consumed each year, it is clearly seen that instead of increasing the number of consumers and the number of industries to be supplied with gas, these numbers must be reduced each year, or the supply of natural gas cannot last for the length of time given by Mr. Wyer. It is encouraging to note that this essential fact is finding its way into the consciousness of many people, and that not a few consumers are beginning to render assistance by curtailing the use of gas where other fuel can be substituted.

Many people are still of the opinion that there is plenty of gas for all. To show how small a quantity of gas has to serve the people of eighty-two townships, it might be well to mention that in the city of Toronto during the year 1921, 5,500,000,000 cu. ft. of gas was manufactured for use in that one city, whereas the total production in the same year by 1,922 gas wells in an area of approximately 6,000 square miles was only 8,532,234,000 cu. ft.

Peak Loads and their Effects

The supply of gas available for any locality is determined by:—

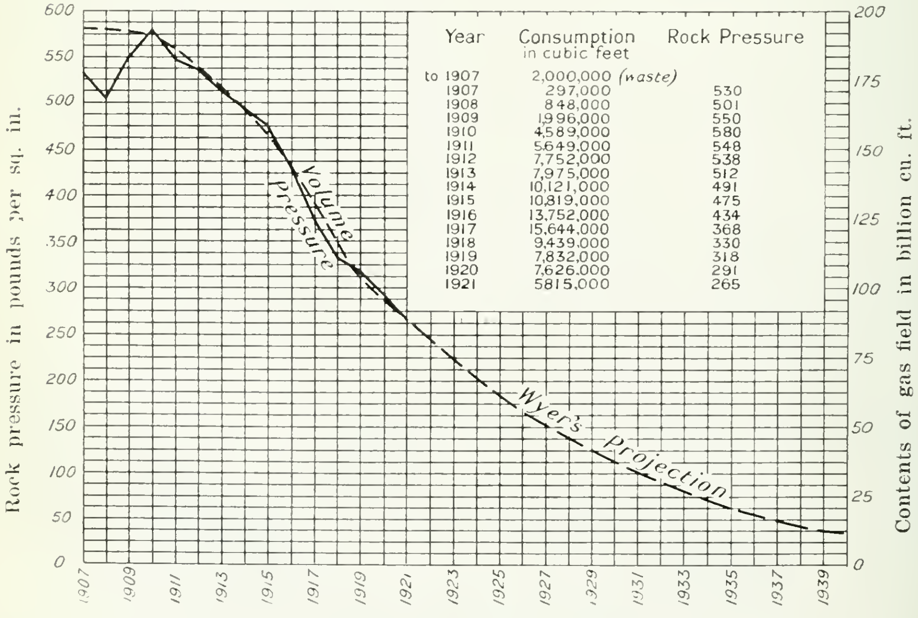
1. The number of gas wells and their rock pressure (i.e., the volume of gas in pounds per square inch which was placed by nature in the microscopic cavities between the sand grains of the rock reservoir).

2. The length and size of the pipe line from the gas field to the place of consumption.

In a city supplied with manufactured gas these two factors are represented by:

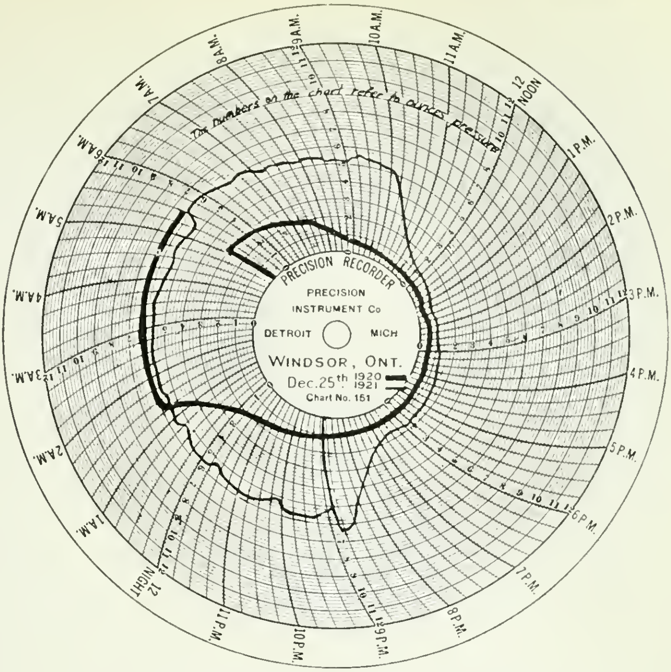
(1) The capacity of the producer plant.

(2) Size of the gas holder.



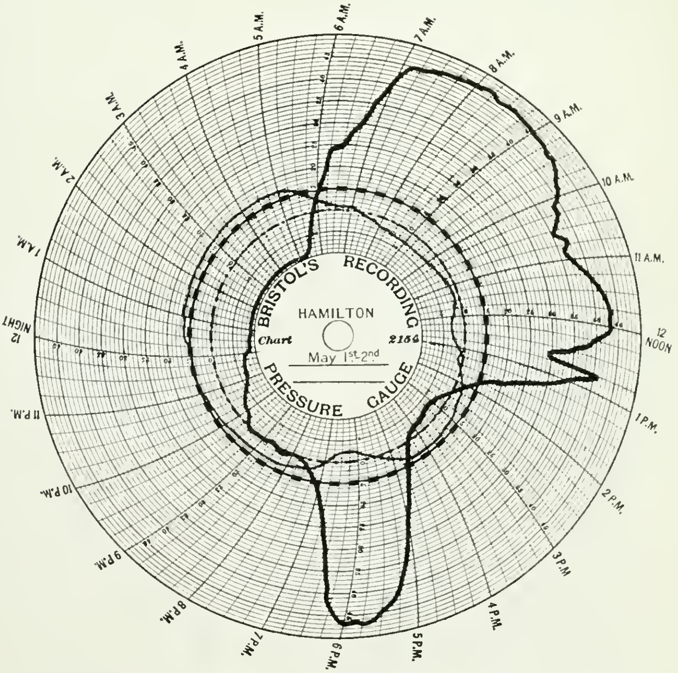
Year	Consumption in cubic feet	Rock Pressure
to 1907	2,000,000 *(waste)*	
1907	297,000	530
1908	848,000	501
1909	1,996,000	550
1910	4,589,000	580
1911	5,649,000	548
1912	7,752,000	538
1913	7,975,000	512
1914	10,121,000	491
1915	10,819,000	475
1916	13,752,000	434
1917	15,644,000	368
1918	9,439,000	330
1919	7,832,000	318
1920	7,626,000	291
1921	5815,000	265

Fig. 3.—Kent gas field showing past and projected future decline of volume and pressure.



━━ Ounces Pressure, Christmas day, 1920.

—— Ounces Pressure, Christmas day, 1921.

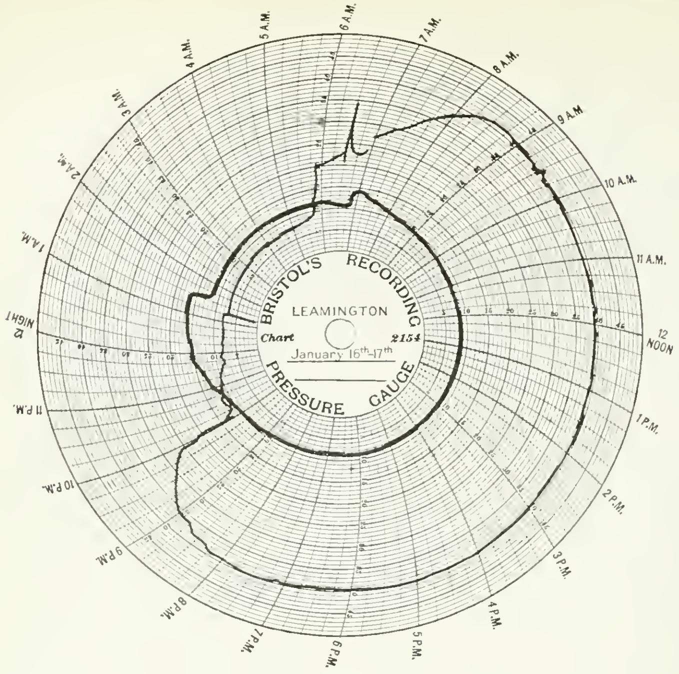


━━ Differential pressure or Rate of Flow under Peak Load conditions.

—— Lbs. Pressure of Gas at the Orifice Meter under Peak Load Conditions.

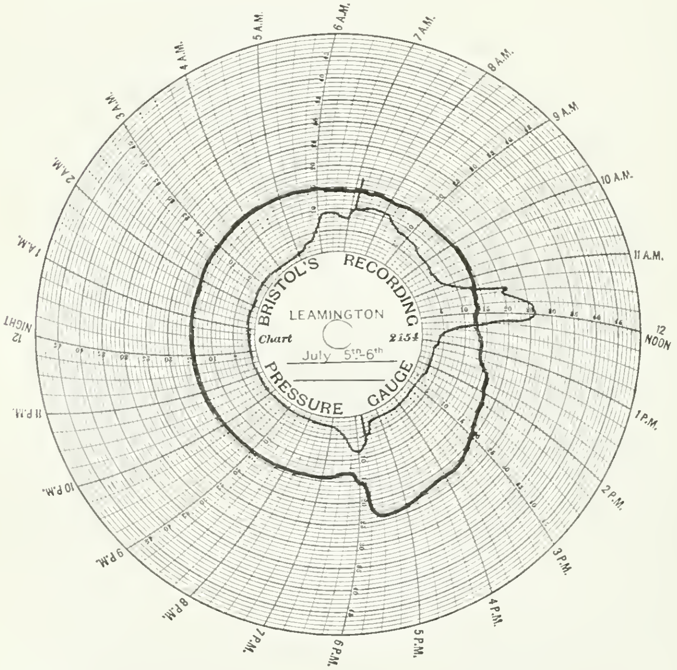
- - - - Rate of Flow if the demand were constant and no Peak Load.

—·—·— Lbs. pressure of gas necessary to supply such constant demand.



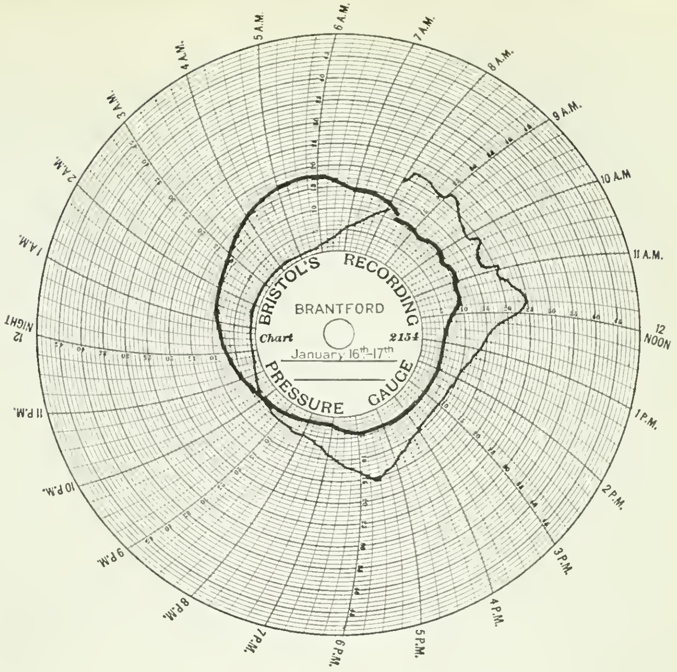
—— Pressure in the High Pressure Gas Mains.

—— Differential Pressure or Rate of Flow in Winter.
The Meter is measuring the full capacity of the Plant for 13 hours.



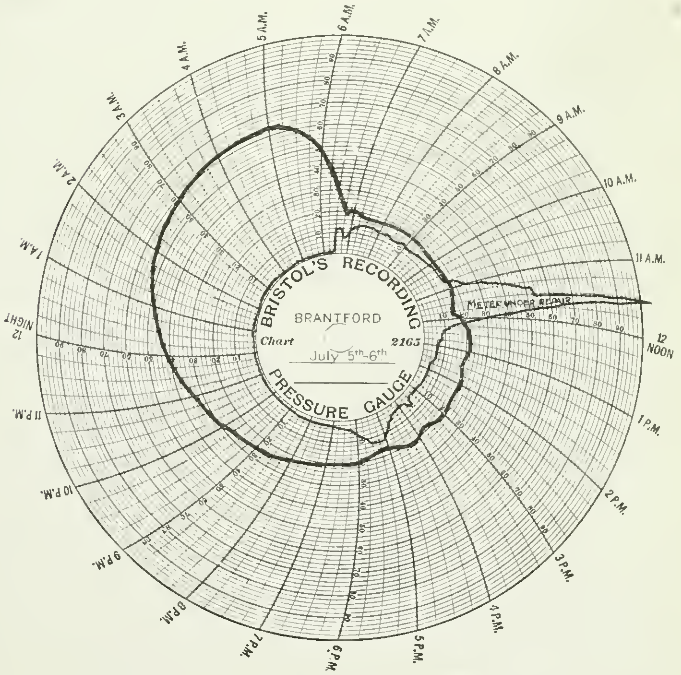
—— Pressure in the High Pressure Gas Mains.

—— Differential Pressure or Rate of Flow in Summer.



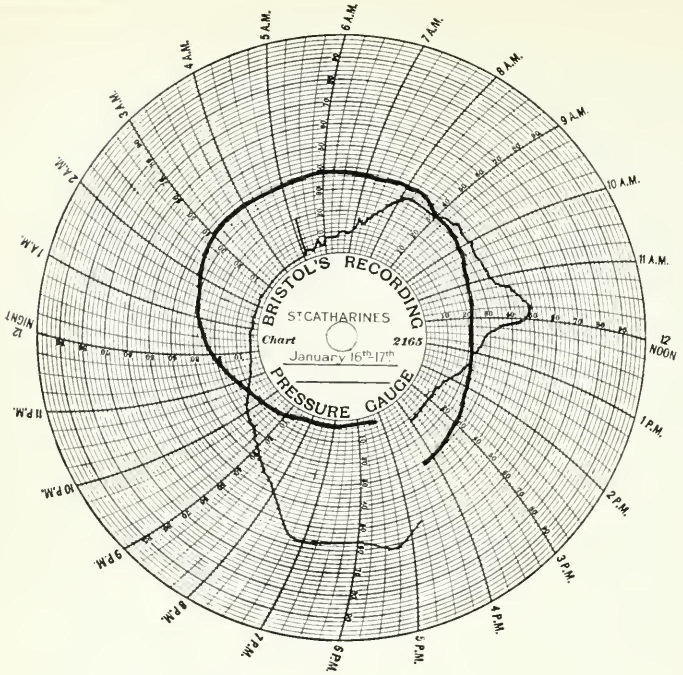
——Pressure in High Pressure Gas Mains.

——Rate of Flow or Winter Demand in Brantford. It does not differ so very much from summer demand.



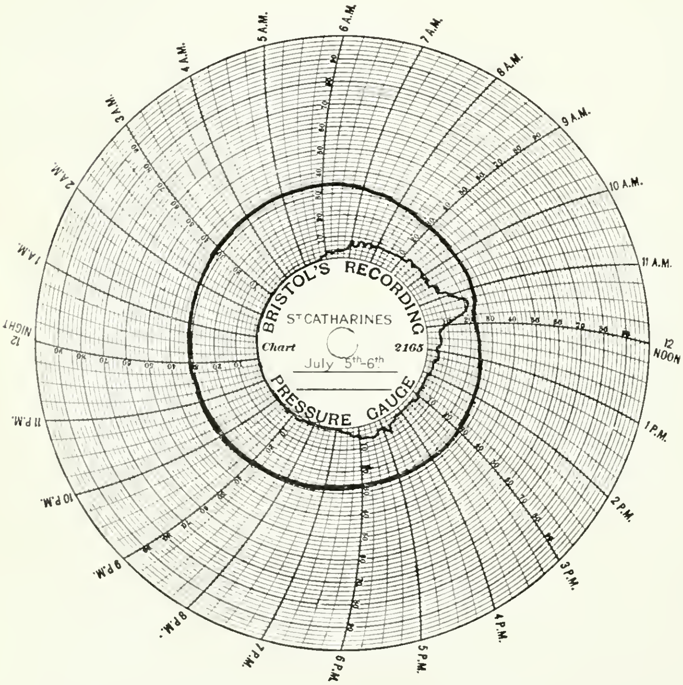
——Pressure in the High Pressure Gas Mains.

——Rate of Flow or Demand in Brantford in Summer.



——Pressure in High Pressure Gas Mains.

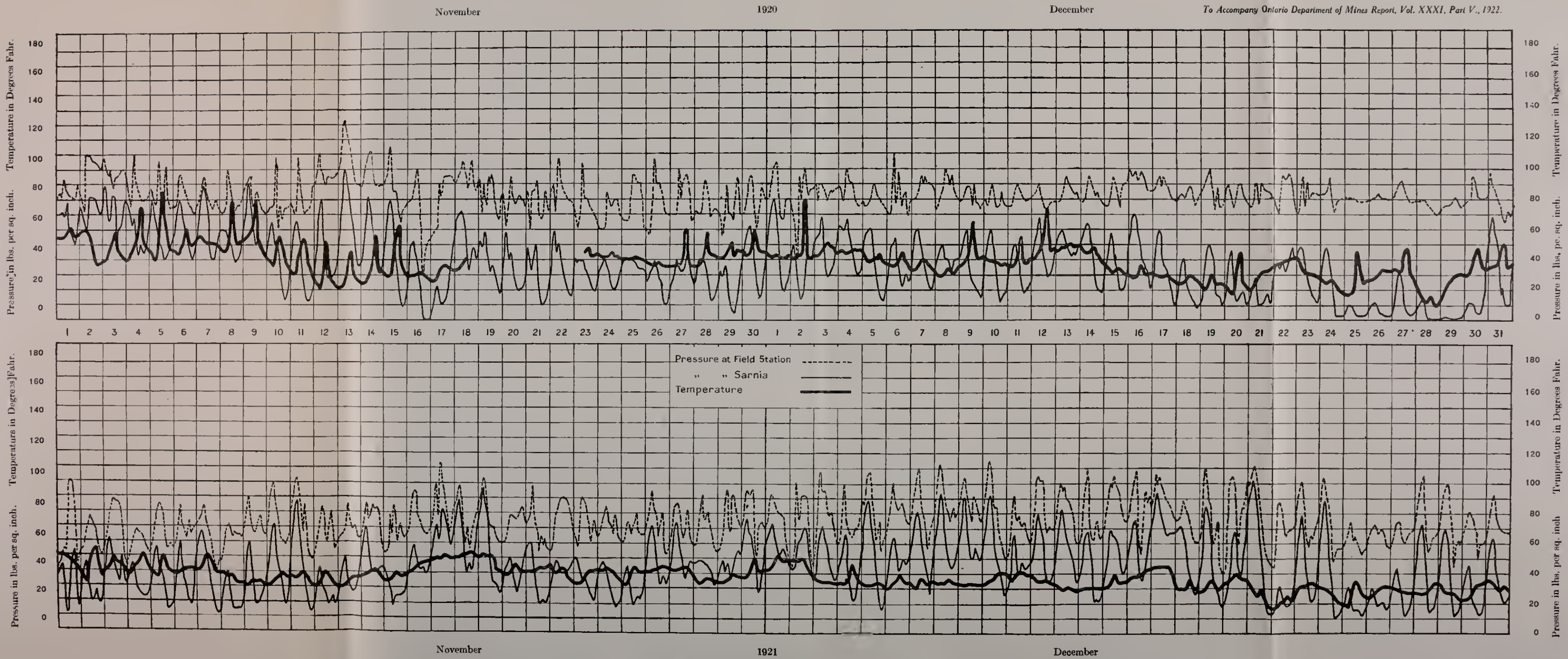
——Rate of Flow or "Demand" in St. Catharines in the Winter.



——Pressure in High Pressure Gas Mains.

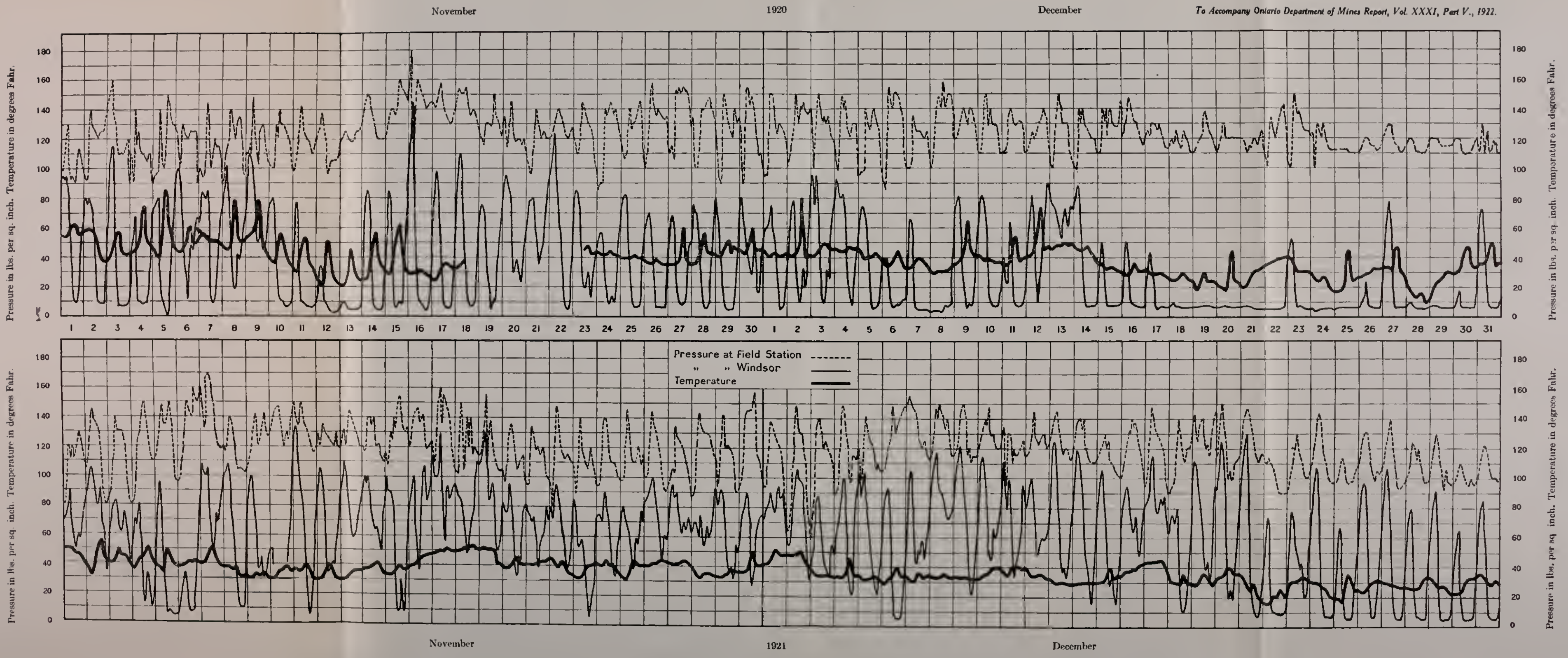
——Demand in St. Catharines in Summer.

To Accompany Ontario Department of Mines Report, Vol. XXXI, Part V., 1922.



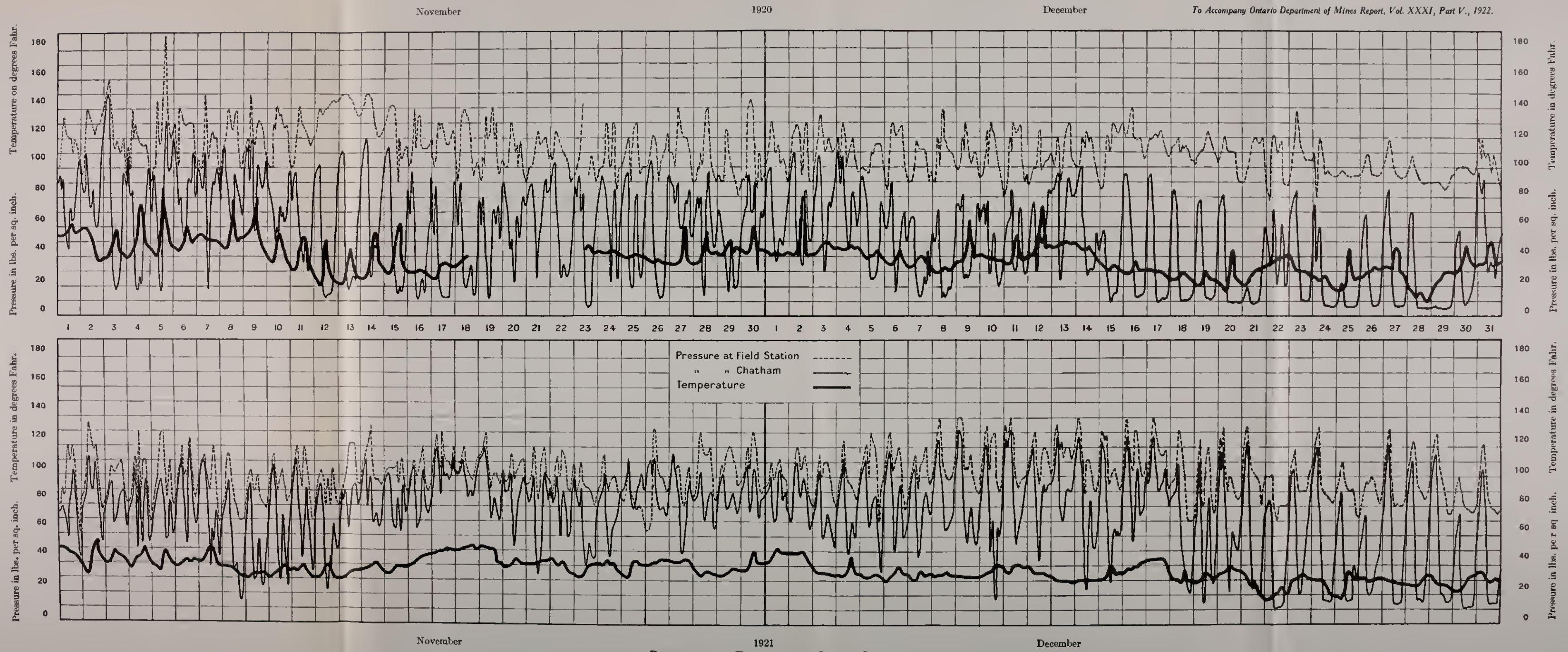
Pressure and Temperature Chart, Sarnia.

To Accompany Ontario Department of Mines Report, Vol. XXXI, Part V., 1922.



Pressure and Temperature Chart, Windsor

To Accompany Ontario Department of Mines Report, Vol. XXXI, Part V., 1922.



PRESSURE AND TEMPERATURE CHART, CHATHAM.

In municipalities only a few miles from the gas field a short pipe line must be packed with gas at a very high pressure, whereas for a municipality a long distance from the field, a long pipe line will hold the same volume of gas at a much lower pressure, and as the pressure on a short line is quickly lowered, more gas wells must be held in reserve to keep up the supply to a nearby municipality than would be required for the one farther away. This can readily be seen by comparing the graphs (see inserts) showing the comparative pressures to Sarnia, Chatham and Windsor. Sarnia and Chatham have nearly the same population, yet there is a much greater variation in pressure at Chatham than at Sarnia.

The same reasoning will show that the distant municipality will get a better and more even service with a lower pressure than the near-by one, but, unfortunately, when the rock pressure becomes very low the demand for the near-by municipality is so great that gas wells must be held in reserve to turn on when the pipe line pressure drops below the minimum necessary for maintaining a supply, and as a result the distant municipality is bound to suffer a shortage.

As the rock pressure in the gas field falls from year to year, peak loads on the near-by municipalities will become more serious, and in the attempt to maintain a good service in such municipalities, those at a distance must suffer for the reason pointed out in the preceding paragraph.

The question of determining when the distant municipality must be finally deprived of its natural gas service is dependent upon the economies that the near-by municipalities will practise.

An examination of the three graphs (inserts) showing pressures at Windsor, Chatham and Sarnia, and the pressure-volume charts, pages 9 to 12, will show that in the early morning the gas pressure begins to drop, and that after six o'clock at night the pressure rises, although between these hours in the past winter the pressure showed signs of recovery. This is explained by the fact that much less gas was being used in the industries last winter than in the one previous, and that between the hours for preparing meals the supply of gas was greater than the demand, thus permitting a rise in the gas pressure. Such an effect, however, is only noticeable on a few occasions, as the demand for heating is so great that only on warm days can any relief be expected.

Peak Loads In Cities and Towns

In cities where very little gas is used for heating purposes and the greater demand is for cooking, the peak load is most in evidence. The orifice meter chart for the city of Hamilton, page 9, shows this peak load. It will be seen that the gas pressure drops from 5 a.m. until 12.30 p.m., recovers from 12.30 p.m. until 4.30 p.m., drops until 6.30 p.m., and recovers until 5 a.m. The differential pressure, which indicates the volume or "rate at which gas flows" shows practically no gas being used from midnight until 5 a.m. The breakfast cooking demand, causing a sudden rush which lasts until 9 a.m., the lesser quantity of gas used between breakfast and noon for baking, washing, etc., the sudden increase again at 11 a.m. until 12 noon, the practical cessation of the demand again until 4.30, when another rise begins culminating at 6 p.m., unmistakably reflect the daily programme of domestic life in the homes of Hamilton gas consumers. To deliver the volume of gas required to cook the meals in a city of 200,000 people requires an efficient system of distribution. The quantity of gas passing through the orifice meter is 1,035,000 cu. ft. in twenty-four hours, and practically all of this gas was used in the daylight hours. If the demand had been uniform during the twenty-four hours, and the same amount of gas passed through the meter, the differential pressure or "rate of flow" would have followed the broken line, and the pressure might have been reduced to ten pounds, as shown by the —.—. line.

Turning to the charts for Leamington, Brantford and St. Catharines, it will be noticed that the noon "peak" is very pronounced in both summer and winter in both Brantford and St. Catharines, while in Leamington there is a uniform daylight load in the winter, and the mealtime "peaks" are in summer. The explanation of this is that the price of gas in Brantford and St. Catharines is higher than in Leamington, and very little is used for heating, while in the latter place, with a lower price, there is a great demand for heating. Still another reason is that the distributing plants of Brantford and St. Catharines have pipes of sufficient size to deliver gas at a four-ounce pressure, while in Leamington the pipes are much too small to supply the demand and pressures vary from ten to twenty-two ounces. The pipes in this town will be enlarged and relaid in 1922, and an improvement in the service will then undoubtedly be noted. Comparing the total load, it will be seen that the St. Catharines consumption on a winter day is 675,000 cu. ft., as against 209,000 cu. ft. in summer, or over three times as much. In Brantford it is 515,000 cu. ft. in winter as against 299,000 cu. ft. in summer, little gas being used for heating in Brantford, while in Leamington the winter consumption is 1,031,000 cu. ft. as compared with 160,000 cu. ft. in summer, or over six times as much. These quantities are calculated by applying a formula and constant multiplier to the line pressure and the differential pressure shown in the chart.

A distributing plant must be designed to deliver all the gas demanded at times of peak loads, and from this it can be clearly seen that if no gas is being used during the night and very little between meals, the gas plant is lying idle and yielding no return about sixty per cent. of the time, hence the rate the consumer pays for gas must be proportionately higher than if there were a constant demand during the twenty-four hours and no peak load. This is further shown by the broken line on the Hamilton chart. The statement is quite as true of transmission lines as it is of distribution plants.

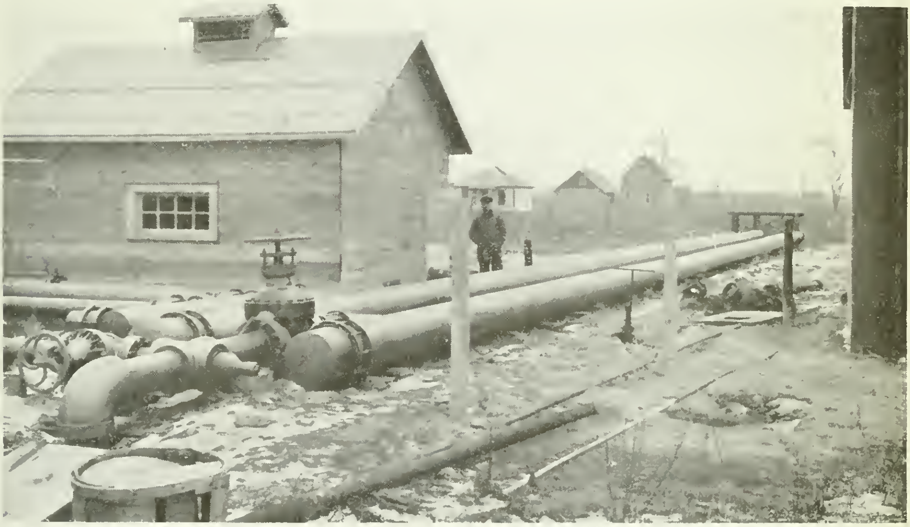
Leakage

It had been hoped to thoroughly discuss the important question of leakage in this report, but on account of the late installation of orifice meters and the fact that there is no check on some companies to date, it would be obviously unfair to single out those companies which are lowering the leakage on their pipe lines and distributing plants, while those which have not yet accomplished much escape notice. Suffice it to say that the leakage on nearly all pipe lines and distributing plants is more than it should be. In some private lines seventy-five per cent. of the gas escapes, and in other pipe lines the loss varies down to permissible and accepted standards of leakage. In every practicable way pressure is being brought to bear on companies and individuals to check this excessive leakage.

Improvements in the Fields

Among the improvements in the methods of transmitting and distributing gas in Ontario during the year 1921, mention may be made of a "dust" or sediment trap, and the installation of a number of large volume orifice meters.

In long distance transmission of natural gas containing sulphuretted hydrogen, it was found increasingly difficult to keep regulators and meters in good condition as the distance from the field lengthened. Investigation proved that the difficulty was due to a deposit of fine dust which clogged some of the working parts and caused excessive friction in others. The dust was found to be iron sulphide which formed in these long pipes, and was carried along with the gas. To remove this dust, the complicated apparatus shown in the photograph was installed. Two lengths of eighteen-inch pipe, each 140 feet long, were laid parallel and tied together at each end by a slightly smaller pipe, and all joints oxyacetylene-welded. The gas enters through an eight-inch pipe into the two eighteen-inch pipes, and the rate of flow is reduced about ten times. This slowing up allows the iron sulphide dust or sediment to settle, and the gas passing up and through the connecting pipe at the distant end of the eighteen-inch pipes to the orifice meters shown on page 4, is almost entirely freed from the dust. This was put in operation in the late autumn, and gave every satisfaction during the winter when it had its most severe test. The estimated total cost of this plant comprising dust trap and orifice meters installed is about $5,500.



Dust trap for removing iron sulphate from natural gas.[1]

Production

The production of natural gas during the year 1921 was 8,532,234,000 cu. ft., which is 2,015,254,000 cu. ft. less than in the previous year. These figures do not include leakage. The falling off in production is due to three causes:

---

[1] Photo supplied by Union Natural Gas Co., Ltd., Chatham, Ontario.

(1) The natural decrease in the quantity of gas which will come out of the rock owing to decrease in the gas pressure.

(2) The many restrictions enforced by the Commissioner in the sale of gas for manufacturing purposes.

(3) The increase in the price of gas, and consequently the more careful use of this valuable fuel.

The total value of gas produced, taken from the returns of the companies, was $2,975,502. Some companies value their output at the price paid them by the companies which distribute the gas, hence the above valuation is at best approximate, being based partly on wholesale and partly on retail prices. The average retail price in 1921 was about forty-five cents per M cu. ft.

Comparing last year's sales with those of 1920, we have the following comparison:—

In 1920:

75,000 domestic consumers used	9,121,000	M cu. ft.
5,000 commercial consumers used	1,424,000	"
Total	10,545,000	"

In 1921:

87,108 domestic consumers used	7,674,493	M cu. ft.
1,000 (estimated) commercial consumers used	857,741	"
Total	8,532,234	"

Omitting the city of Hamilton, where the natural gas is mixed with manufactured gas, there were in 1921, 65,962 consumers using 7,116,032 M cu. ft., an average of 107,000 cu. ft. per consumer, which compares very favourably with the average quantity used at that price on this continent.[1]

Although it is possible that the number of domestic and industrial consumers reported in 1920 was in part estimated, yet even if the number of domestic consumers was the same in both years they used 1,446,507 M cu. ft. of gas less in 1921 than in 1920, and the improvement in service is clearly seen in this report. This is ground enough upon which to base the statement that the methods adopted for conserving the natural gas supply are in the interest of the public.

Below is a table giving particulars regarding the consumption of natural gas in cities, towns and villages during 1921. It shows the quantities used for ordinary domestic purposes, also in industrial operations, the prices paid, and other particulars. This is followed by a table giving similar information with respect to the use of gas in township municipalities.

---

[1] Rep. Ont. Dept. Mines., Vol. XXX, 1921, Pt. 5, p. 13.

TABLE I.—CONSUMPTION OF NATURAL GAS IN TOWNS AND CITIES, 1921.

City, Town or Village	Population[1]	No. of consumers		Amount used in 1921 M. cu. ft.			Distance from gas field, miles	Rate, cents per M. cu. ft.
		Free	Pay	Free	Pay	Industrial		
Aylmer	2,094		742		45,539	369	12	60&75
Bridgeburg	2,401	3	974	499	60,876	174	8	50&75
Fort Erie	1,546							
Belmont			140		6,492		94	75
Blenheim	1,565		516		68,027	576	20	45
Belle River	608		149		17,306	1,092	29¾	45
Brantford	29,440		1,537		152,544	5,318	141	80
Chippawa	1,137	4	72	500	2,642		3	40
Caledonia	1,223		426		50,753	4,934	6½	40&45
Courtright	448		217		25,389	1,236	53¼	45
Chatham	13,256		3,600		564,182	47,135	22	45
Cayuga	784		209		27,456			45
Dunnville	3,224	5	916	373	109,136	13,962	12	42&45
Dundas	4,978		1,041		38,377	873	172	70
Delhi	733		246		20,764	1,264	26	45
Dresden and Tupperville	1,339		527		61,034	16,724	30	45
Dutton	813		269		34,424	1,226	52	30
Essex	1,588		412		55,544	15,046	33	45
Fonthill	600		150		8,933		25	70
Galt	13,216		1,572		73,002	2,637	147	80
Hamilton	114,151		21,146		55,846	61,578	166	
East Hamilton			413		16,828		27	75
Highgate	394		124		18,802	20	32	20
Hagersville	1,169		365		33,712		13¼	50
Hepworth	317		20		1,250		½	50
Ingersoll	5,150	1	1,225	124	99,342	6,112	100	80
Jarvis	485		240		31,688	2,129	9	43
Kingsville	1,783		576		80,284	107,802	30	40
Leamington	3,675		1,135		182,959		20	40
Niagara Falls	14,764		2,878		132,782	561	11	50&70
Oil Springs	490	15	140	1,000	7,912	1,806	1	75
Petrolia	3,148		820		107,982	4,158	60	50
Paris	4,368	1	641	171	31,363	375	129	80
Rodney	756		240		32,754	148	40	28
Ridgetown	1,855		637		74,106	12,543	28	45
Sarnia	16,135		3,950		522,924	13,161	55¼	40&50
Simcoe	3,953		1,501		206,508	9,757	20	45
St. Catharines	19,881		3,414		161,810	2,395	35	75
Thorold	4,825		445		24,565	62,418	30	75
Merritton	2,542							
Tilbury	1,673		402		47,532	15,744	13½	35
Tecumseh	978		133		15,448		50	45
Tillsonburg	2,974		930		76,507	3,204	14	47
Vienna	288		131		13,198			45&65
Welland	8,654	3	1,959	282	91,826	705	3	50&70
Sandwich	4,415		470		60,786		43¼	40&50
Ford	5,870		440		56,907		43¼	40&50
Walkerville	7,059		1,403		174,972	6,482	43¼	40&50
Windsor	38,591		7,209		918,593	13,768	43¼	40&50
Wallaceburg	4,006		1,100		139,627	209,690	27½	40&50
Wheatley	378		142		18,868		3	25
Woodstock	9,935	1	2,150	117	112,316	5,036	108	80
West Lorne	755		208		30,306	576	45	28
Port Colborne	3,415		1,241		102,838	9,133		50
Humberstone	1,524							
Port Rowan	672		250		21,366		3	52
Port Dover	1,462		474		52,929	9,787	29	45
All Gas Companies for power purposes						140,816		
Total		33	75,263	3,066	5,677,365	812,470		

---

[1] From Dominion Bureau of Statistics, 1921 Census.

TABLE II.—CONSUMPTION OF NATURAL GAS IN TOWNSHIPS, 1921.

Townships	Population	No. of consumers		Quantity used in 1921, M. cu. ft.			Rate, cents per M. cu. ft.
		Free	Pay	Free	Pay	Industrial	
Essex County—							
Gosfield North	1,977	4	117	147	16,310	....	36&89
Gosfield South	2,427	.....	415	....	57,851	....	36&89
Maidstone	2,225	12	471	2,291	59,838	....	45
Rochester	1,911						
Sandwich South	1,391						
Sandwich West	3,519						
Sandwich East	2,348						
Mersea	3,356	.....	132	....	17,549	....	30
Tilbury North	1,699	2	181	364	22,560	3,548	45
Tilbury, West	1,533						
Lambton County—							
Enniskillen	3,063	....	667	....	77,861	....	45
Moore	3,320						
Sombra	2,865						
Sarnia	2,583	1	11	21	1,800	....	45
Euphemia	1,543	.....	20	....	6,667	....	25
Kent County—							
Raleigh	4,343	168	1,537	54,934	245,284	35,165	17&35
Dover	4,345						
Tilbury East	3,197						
Romney	1,563						
Harwich	4,124	17	688	6,979	112,026	100	17, 25 & 45
Orford	1,814						
Howard	2,507						
Chatham	5,272	2	33	565	3,480	....	45
Camden	2,021	.....	8	....	960	....	45
Elgin County—							
Aldboro	2,906	5	28	429	3,324	....	25
Dunwich	2,581	3	122	302	14,623	579	40
Southwold	3,211	1	163	52	26,203	3,465	505
Malahide	2,748	.....	65	....	5,428	....	35&7
Bayham	3,438	8	356	1,337	33,291	....	35, 42, 47&65
Middlesex County—							
Westminster	5,258	.....	247	....	24,134	....	66&70
Dorchester North	3,104	.....	137	....	12,199	480	60&70
Norfolk County—							
Houghton	1,165	.....	15	....	966		47
Middleton	2,057	7	7	2,143	418	....	42
Walsingham	2,553	9	98	1,126	7,940	....	52
Charlotteville	2,492	6	114	1,322	9,796	....	45
Windham	2,950	3		586			45
Woodhouse	1,669	17		2,385			45
Brant County—							
Onondaga	1,134	10	206	1,572	12,560	....	45&80
Dumfries South	2,391	.....	140	....	7,288	94	80
Oxford County—							
West Oxford	....	.....	7	....	341	....	80

TABLE II.—*Continued*

Townships	Population	No. of consumers		Quantity used in 1921, M. cu. ft.			Rate, cents per M. cu. ft.
		Free	Pay	Free	Pay	Industrial	
Haldimand County—							
Canborough	997	46	76	7,551	6,783	....	42½
Moulton	1,609	34	87	6,116	7,861	....	25&60
Seneca	1,742	67	136	10,634	11,699	....	30&45
North Cayuga	1,423	15	35	2,776	3,856	....	35
South Cayuga	591	28	59	5,737	4,616	....	42½
Rainham	1,731	105	272	21,366	29,705	....	25
Sherbrooke	316	1	26	250	2,661	....	40&50
Dunn	788	27	115	2,814	12,188	....	20&42
Walpole	3,311	46	297	8,481	29,265	1,131	26&45
Oneida	1,377	10	69	1,331	7,399	....	40&50
Welland County—							
Wainfleet	2,582	42	117	7,027	6,655	....	35&70
Humberstone	2,304	58	158	11,709	6,885	....	50
Bertie	3,305	85	1,041	17,071	38,044	485	60
Pelham	2,600	5	136	1,110	9,000	....	57
Thorold	2,885	1	153	169	9,161	....	50&70
Willoughby	917	38	53	7,904	1,824	....	50&70
Crowland	3,826	29	58	5,179	3,956	....	50
Stamford	4,000	......	239	....	8,222	....	50&70
Lincoln County—							
Caistor	1,300	32	28	5,041	4,880	....	25&42½
Gainsboro	2,117	1	42	50	2,314	224	35&75
Grimsby	2,879	41	140	12,147	8,310	....	75
Louth	2,312		10		710	....	57
Grantham	3,456	1	17	881	1,200	....	57
Wentworth County—							
Binbrook	1,260	37	86	6,799	13,049	....	25&42½
Glanford	1,409	9	84	1,452	9,356	....	25&42½
Barton	10,165	......	923	....	73,614	....	40
Flamboro West	2,423	......	34	....	1,258	....	70
Ancaster	4,058	......	1	....	1,326	....	25
Total	....	758	4,492	143,595	315,797	1,840	....

These two tables of gas consumption in the cities, towns and townships of Ontario is not given as correct in detail. In procuring the data for the same, it was found difficult to segregate gas users in one township from those in an adjoining one, or in a group of townships, the gas companies not finding it necessary to keep a separate ledger for each township. Again, many houses and small gas engines may be supplied with gas passing through the same meter, and on account of the relatively small consumption, this gas has been classed as for domestic use. The number of consumers is probably correct, but the quantity of gas consumed may in some cases not be so. This applies more particularly to country and village users. In cities and large towns separate ledgers are usually kept, and more precise figures are available. The tables, however, approximate the true situation and show where most gas is used, and also how the price affects the quantity consumed. It will be noted that the total gas consumed as shown in the tables is not the same as the total quantity of gas produced in 1921. This is explained by the fact that no private wells are included and no leakage.

TABLE III.—CLASSIFICATION BY INDUSTRIES OF NATURAL GAS USED IN ONTARIO FOR INDUSTRIAL PURPOSES IN 1921 (1)

Municipality.	Factory Heating, Incinerator.	Gas Engines and Power	Soldering, Hardening metals, Tempering, Annealing	Enamelling	Laundries, Tailors, Cleaners,	Printing	Packing, Canning	Heating glue wax, water, etc.	Bakers, Confectioners, Restaurants	Dairies	Laboratories	Glass Mfg., Tobacco Curing	Clay Workers, Lime kilns	Greenhouses	Total (M. cu. ft.)
Aylmer		273							96						369
Belle River		658	67						367						1,092
Belmont		161							101						262
Blenheim		263				70			211				2		576
Brantford		1,042	2,014	883	100	106		78	1,005				90		5,318
Bridgeburg								123							123
Caledonia	3,591	432							911						4,934
Chatham		7,984	9,150	2,045		1,914	1,093		5,060	3,798			16,091		47,135
Chatham district		7,880				110			958				13,802		22,750
Coatsworth		332											11,214		11,546
Comber		1,020							380				2,148		3,548
Courtright		1,236													1,236
Delhi		1,264													1,264
Dresden		16,112							612						16,724
Dundas		194	679												873
Dunnville		9,574	3,111							1,277					13,962
Dutton		723							503						1,226
Essex	331	7,785							1,583		168		5,176		15,046
Fort Erie		51													51
Galt		93	1,705	115				691							2,637
Hamilton		82	(3) 28,598	7	63		355	1,793	331	7,887	108		22,354		61,578
Highgate		20													20
Ingersoll		1,387	112				297	150	1,166						6,112
Jarvis		2,129													2,129
Kingsville		39,133	379		1,457	63	401		1,621	652		(4) 48,861		15.246	107,802
Muirkirk		100													100
Niagara Falls			519					52							561
Oil Springs		1,806													1,806
Paris		80						295							375
Petrolia		1,545			353				1,349				911		4,158
Port Colborne				9,133											9,133
Port Dover		607	91			448							8,171	470	9,787
Prairie Siding		869													869

Putman		218													218
Ridgetown		1,595	2,818		231				1,052	86			8,761		12,543
Ridgeway		182													182
Rodney		148													148
Sarnia district		3,947												233	4,180
Sarnia		4,505	1,308		331	241			1,558	1,038					8,981
Selkirk		1,131													1,131
Simcoe		51					7,065	2,273		368					9,757
St. Catharines			2,395												2,395
St. George		94													94
Shedden-Fingal		3,465													3,465
Stevensville		303													303
Thorold												62,418			62,418
Tilbury		14,472					147		835				198	92	15,744
Tillsonburg		576	338					14	2,276						3,204
Wallaceburg		72,277	1,181			207			2,276			133,746	3		209,690
Walkerville	(2) 1,287		3,439	236				139	1,149			132			6,382
Welland					592	113									705
Wellandport	118	87								19					224
West Lorne	126	380					70								576
Wallacetown		579													579
Windsor			2,858	1,906	21	226	332	2,713	5,475	94	243				13,868
Woodstock			843		491	520		186							5,036
All Gas Companies		140,816													140,816
Total (M. cu. ft.)	5,456	349,650	61,605	14,355	3,639	4,018	9,760	8,500	36,640	15,219	912	245,025	86,921	16,041	857,741

(1) The quantities are in thousand cubic feet. (2) Incinerator. (3) Annealing—14,412 M. cu. ft. (4) Tobacco Curing.

Ratio of price to Gas consumed

At the various rate hearings during the year 1921, it was stated several times that the rates charged for gas had very little to do with conserving gas. A glance at Tables I and II will show at once that it has very much to do with conserving gas. For instance:

Place	No. Consumers	Rate cents	Amount used, M. cu. ft.	Average per Consumer M. cu. ft.
4 Townships in Kent County	168	Free	54,934	321
" [illegible]	1537	35 and 17	245,284	160
Dutton................	269	30	34,424	128
Dundas................	1041	70	38,377	37

These places have been taken at random. Averaging all places where rates are equal may give a slightly different result.[1] The comparison is only made to show that careless use of gas does exist, and that the steps taken to curtail needless consumption of gas are justified. Surely there is no need of anyone using 321,000 cu. ft. of gas when his neighbour has the same result from 160,000 cu. ft.

When the price of gas is advanced beyond fifty cents apparently other fuels come into competition for heating purposes, but where the price of gas is below fifty cents it is undoubtedly used for all purposes. The degree of care used in conserving gas will be seen to decrease in direct proportion with the decrease in price.

There is also a rate above or below which profits decrease. One company puts this maximum rate at eighty cents.

It has often been stated that electricity is a cheaper and better fuel for cooking than natural gas. A glance at the number of consumers, rate, and amount of gas used in Niagara Falls, where electricity is cheapest, should be sufficient to convince the most skeptical that this is not correct.

It is of considerable interest to know for what particular purposes natural gas is used, in industrial or manufacturing operations. There are certain trade and even agricultural operations for which gas is so convenient and advantageous a fuel, as compared with any other, that it is difficult to deny them the use of gas if it can at all be spared. Table III classifies by industries the industrial uses of gas in 1921.

---

[1] Ont. Dept. of Mines, Vol. XXX, Pt. 5, p. 13.

The following list gives the names and addresses of operators licensed to produce natural gas in 1921:—

OPERATORS LICENSED TO PRODUCE NATURAL GAS, 1921

License No.	Name	Address
105	Aldrich Gas & Oil Co.	Bruce & Counsel, Hamilton, Ont.
122	Beer, George	Binbrook, Ont.
130	Beaver Oil & Gas Co., Ltd.	Brantford, Ont.
137	Bertie Natural Gas Co.	Ridgeway, Ont.
139	Battle Natural Gas Co.	Sun Life Bldg., Hamilton, Ont.
142	Binbrook Gas Co.	N. Laidman, Binbrook, Ont.
134	Castle Oil & Gas Co., Ltd.	Niagara Falls, Ont.
141	Chippawa Development Co.	Chippawa, Ont.
148	Chippawa Oil & Gas Co.	Tavistock, Ont.
129	Coleman, J. A.	Wellandport, Ont.
118	Canfield Natural Gas Co.	W. W. Thompson, Canfield, Ont.
104	Canby, B. F.	R.R. No. 2, Marshville, Ont.
147	Canboro Gas & Oil Co., Ltd.	Selkirk, Ont.
110	Darling Road Co-op. Co., Ltd.	Canfield, Ont.
146	Dunn Natural Gas Co.	Dunnville, Ont.
131	Dominion Natural Gas Co.	Brantford, Ont.
115	Empire Limestone Co.	191 Hudson St., Buffalo, N.Y.
144	Emerson, Laidlaw, Troughton	R.R. No. 1, Attercliffe Station, Ont.
127	Glenwood Natural Gas Co.	638 Ellicott Sq., Buffalo, N.Y.
108	Hamilton Gas & Oil Co.	17 Main St., E. Hamilton, Ont.
145	Hendee Gas Co.	Cayuga, Ont.
119	Industrial Natural Gas Co.	Thorold, Ont.
116	Jasperson, B.	Kingsville, Ont.
124	Lalor & Vokes	Dunnville, Ont.
123	F. R. Lalor	Dunnville, Ont.
112	Lamb, A.	Selkirk, Ont.
143	Midfield Natural Gas Co.	9 Maple Ave., Hamilton, Ont.
136	Medina Natural Gas Co.	Chatham, Ont.
135	Marshall, James	Hamilton, Ont.
132	National Gas Co.	Hamilton, Ont.
106	North Shore Gas Co.	c-o Bruce & Counsel, Hamilton, Ont.
121	Northern Gas & Gasoline Co.	Hepworth, Ont.
125	Ontario Gypsum Co.	Paris, Ont.
109	Oil Springs Oil & Gas Co.	Oil Springs, Ont.
113	Provincial Natural Gas Co.	Niagara Falls, Ont.
117	Port Colborne-Welland Natural Gas Co.	Port Colborne, Ont.
103	Pilkington Bros.	Thorold, Ont.
133	Petrol Oil & Gas Co.	1804 Royal Bank Bldg., Toronto, Ont.
140	Richmond Gas Co.	Chatham, Ont.
138	Sparham, A. F.	R.R. No. 1, Caledonia, Ont.
120	Sterling Natural Gas Co.	Port Colborne, Ont.
114	Stevensville Gas Co.	Stevensville, Ont.
111	Sundy Gas Well Co.	J. Ralston, Dunnville, Ont.
126	Union Natural Gas Co.	Chatham, Ont.
128	United Gas Companies	St. Catharines, Ont.
107	Vacuum Oil & Gas Co., Ltd.	608 Lumsden Bldg., Toronto, Ont.

The individuals, firms and companies duly licensed to drill or bore for natural gas were:—

OPERATORS LICENSED TO DRILL OR BORE FOR NATURAL GAS, 1921

License No.	Name	Address
50	Berry & Anderson	Caledonia, Ont.
63	J. A. Coleman	Wellandport, Ont.
66	Chamberlain, H. A	Shelburne, Ont.
70	Clover Gas & Oil Co., Ltd.	Raymond & Spence, Welland, Ont.
68	Featherstone, C. W.	Canboro, Ont.
69	Featherstone, C. W.	Canboro, Ont.
71	Hoover & May	Selkirk, Ont.
58	Industrial Natural Gas Co.	Thorold, Ont.
72	Imperial Oil Co., Ltd	56 Church St., Toronto, Ont.
56	Jasperson, Bon	Kingsville, Ont.
64&65	Kiser & Louer	Tillsonburg, Ont.
59	McCutcheon, T. J	Dunnville, Ont.
60	McLister, J. J.	Dunnville, Ont.
57	McKillop, Wm.	Hepworth, Ont.
55	Provincial Nat. Gas & Fuel Co.	Niagara Falls, Ont.
51,52&53	Snively, F. L.	90 Melrose Ave., Hamilton, Ont.
67	Stover, F. H.	110 Canfield Ave., E. Detroit, Mich.
54	Universal Gas & Oil, Ltd.	c-o Millar, Ferguson & Hunter, Crown Life Bldg., Toronto, Ont.
62	Union Exploration Co., Ltd.	Chatham, Ont.
73	Featherstone, C. W.	Dunnville, Ont.
87	McKeehnie, Sam	Dunnville, Ont.

Companies operating pipe lines under license were as follows:—

OPERATORS LICENSED TO OPERATE NATURAL GAS PIPE LINES, 1921

License No.	Name	Address
24	Beaver Oil & Gas Co.	638 Ellicott Sq., Buffalo, N.Y.
26	Castle Oil & Gas Co.	Niagara Falls, Ont.
27	Central Pipe Line Co.	Chatham, Ont.
25	Dominion Natural Gas Co.	638 Ellicott Sq., Buffalo, N.Y.
23	Glenwood Natural Gas Co.	Brantford, Ont.
19	Northern Pipe Line Co.	Chatham, Ont.
21	Southern Ontario Gas Co.	638 Ellicott Sq., Buffalo, N.Y.
22	United Gas Companies	St. Catharines, Ont.
20	Union Natural Gas Co., Ltd.	Chatham, Ont.

Distributors of natural gas duly authorized to carry on operations in 1921 were as follows:—

OPERATORS LICENSED TO DISTRIBUTE NATURAL GAS, 1921.

License No.	Name	Address
98	Azoff Natural Gas Co.	c/o A. Baker, Canfield, Ont.
99A	Beer, George.	Binbrook, Ont.
112	Bertie Natural Gas Co.	Ridgeway, Ont.
91	Belmont Gas Light Co.	Belmont, Ont.
96	Brantford Gas Co.	Brantford, Ont.
105	Beaver Oil & Gas Co.	Brantford, Ont.
114	Binbrook Gas Co.	Binbrook, Ont.
103	Coleman, J. A.	Wellandport, Ont.
111	Central Pipe Line Co.	Chatham, Ont.
115	Chippawa Development Co.	Chippawa, Ont.
89	Corp. Town of Leamington	Leamington, Ont.
83	Chatham Gas Co.	Chatham, Ont.
110	Castle Oil & Gas Co.	Niagara Falls, Ont.
112	Chippawa Oil & Gas Co.	c/o A. E. Ratz, Tavistock, Ont.
104	Dominion Natural Gas Co.	638 Ellicott Sq., Buffalo, N.Y.
119	Dunn Natural Gas Co.	Dunnville, Ont.
88	Fisherville Gas Co.	c/o Chris. Held. Fisherville, Ont.
120	Gas & Oil Co., of Springvale.	c/o W. B. Shoup, Hagersville, Ont.
102	Glenwood Natural Gas Co.	638 Ellicott Sq., Buffalo, N.Y.
121	High Grade Natural Gas Co.	c/o R. L. Pattinson, Chatham, Ont.
92	Industrial Natural Gas Co.	Thorold, Ont.
107	Ingersoll Gas Light Co.	Ingersoll, Ont.
117	Lake Shore Natural Gas Co.	294 Baynes St., Buffalo, N.Y.
123	Kerlin, R. G.	234 Lister Bldg., Hamilton, Ont.
113	Midfield Natural Gas Co.	9 Maple Ave., Hamilton, Ont.
100	Manufacturers Gas Co.	638 Ellicott Sq., Buffalo, N.Y.
93	Northern Gas & Gasoline Co.	Hepworth, Ont.
84	Oil Springs Oil & Gas Co.	Oil Springs, Ont.
85	Petrolia Utilities Co.	Petrolia, Ont.
86	Provincial Natural Gas & Fuel Co., Ltd.	Box 55, Niagara Falls, Ont.
87	Port Colborne-Welland Gas Co.	Port Colborne, Ont.
95	Rosehill Natural Gas Co.	c/o G. A. Halbin, Department of Assessment, 15 City Hall, Buffalo, N.Y.
94	Sterling Gas Co.	Port Colborne, Ont.
109	Sarnia Gas Co.	Sarnia, Ont.
118	Shetland Gas Co.	c/o L. H. Badgeley, Florence, Ont.
97	Southern Ontario Gas Co.	638 Ellicott Sq., Buffalo, N.Y.
99	Union Natural Gas Co., Ltd.	Chatham, Ont.
101	United Gas Companies.	St. Catharines, Ont.
116	United Gas & Fuel Co.	Hamilton, Ont.
90	Windsor Gas Co.	Windsor, Ont.
108	Wallaceburg Gas Co.	Wallaceburg, Ont.
106	Woodstock Gas Light Co.	Woodstock, Ont.

The following list contains the names and addresses of those to whom licenses were issued to lease lands for gas purposes, and to prospect for gas in 1921.

OPERATORS LICENSED TO LEASE AND PROSPECT FOR NATURAL GAS, 1921.

License No.	Name	Address
92	Abray, Thomas	Highgate, Ont.
76	Beaver Oil & Gas Co., Ltd	Buffalo, N.Y.
86	Bermingham, T. F.	55 John St., S. Hamilton, Ont.
59	Bunn, Forest	Ruthven, Ont.
81	Castle Oil & Gas Co., Ltd	Imperial Bank Bldg., Niagara Falls.
68	Clover Gas & Oil Co., Ltd.	1711 Main St., Buffalo, N.Y.
75	Dominion Natural Gas Co., Ltd	638 Ellicott Sq., Buffalo, N.Y.
73	Frontier Oil & Gas Co., Ltd	211 Liberty Bldg., Buffalo, N.Y.
72	Glenwood Natural Gas Co., Ltd	638 Ellicott Sq., Buffalo, N.Y.
90	Irvine, J. J	Victoria Hotel, Dunnville, Ont.
89	Inland Oil & Gas Co., Ltd	Kent Bldg., Toronto, Ont.
67	Industrial Natural Gas Co	Thorold, Ont.
84	Jasperson, Bon	Kingsville, Ont.
77	Keyser, Bert L.	21 London St., Toronto, Ont.
70	Milkins, H. R., Jr	R.R. No. 2, Leamington, Ont.
69	Minor, L. E.	Smithville, Ont.
63	Maple Leaf Oil & Gas Co., Ltd	14 Brisbane Bldg., Buffalo, N.Y.
78	Petrol Oil & Gas Co., Ltd	1804 Royal Bank Bldg., Toronto, Ont.
65	Provincial Natural Gas & Fuel Co., Ltd.	Box 55, Niagara Falls. Ont.
61	Pilkington Bros., Limited	Thorold, Ont.
66	Progressive Gas & Oil Co., Ltd	38 Sun Life Bldg., Hanilton, Ont.
79	Quillinan, J. A	Drawer 119, Niagara Falls, Ont.
88	Robnett, C. W.	Merlin, Ont.
80	Symes, H. D.	Imperial Bank Chambers, Niagara Falls, Ont.
82	Snively, F. L.	90 Melrose Ave., Hamilton, Ont.
93	Staehling, E. H.	Merlin, Ont.
94	Smith, R. H.	Lowbanks, Ont.
95	Sparham, A. F.	Caledonia, Ont.
91	Smith, H. B.	117 Oak Ave., Windsor, Ont.
60	Thames Oil & Gas Co	24 Adelaide St., Toronto, c/o T B. Malone
64	Universal Gas & Oil, Ltd	Crown Life Bldg., Toronto, Ont.
71	Union Exploration Co., Ltd.	Chatham, Ont.
83	Valley Oil & Gas Co	42 Home Bank Bldg., Hamilton, Ont.
85	Western Counties Gas Co	Bradford & Bradford, Dunnville, Ont.
62	Winger, S. W.	R.R. No. 4, Hagersville, Ont.
74	Williams, A.	Leamington, Ont.
87	Wiles, Chas. H.	R.R. No. 2, Dunnville, Ont.

Field Operations in 1921

The field operations for the year 1921 are shown in the following table, which indicates the efforts that are being made to locate and open up new reservoirs of gas, and the degree of success attending them.

Table IV shows the field operations for the year. It is gratifying to compare this record with that for 1920, when out of a total of 94 wells drilled 21 were dry and 73 produced in daily open flow only 9,203,000 cu. ft.

TABLE IV.—NATURAL GAS WELLS DRILLED, 1921

County	Township	Number of Wells Abandoned in 1921	Number of Dry Wells Drilled in 1921	Producing Wells Drilled in 1921		Number of Producing Wells on Dec. 31st, 1921
				Number	Open Flow	
					cu. ft.	
Brant	Onondaga	4				53
Bruce	Amabel					2
Elgin	Aldborough	1				
	Bayham	1		1	75,000	56
	Malahide		2	1	200,000	1
Essex	Gosfield S.			1	17,000	1
	Mersea			1	25,000	4
Haldimand	Canboro	6		4	201,000	158
	Cayuga North		3	4	538,435	44
	Cayuga South	1				62
	Dunn	1		1	100,000	20
	Moulton	2		7	266,000	91
	Oneida			9	763,000	23
	Rainham	9				122
	Seneca	7	3	28	3,030,000	161
	Sherbrooke	1	1	2	280,000	14
	Walpole	16	2	4	225,000	157
Kent	Dover West	1	2	1	60,000	8
	Raleigh	3		1	1,000,000	24
	Romney	2				95
	Tilbury East	13	1	12	4,288,000	147
Lambton	Dawn	1		1	177,000	1
	Enniskillen					4
	Euphemia					6
	Sarnia	3		11	2,400,000	14
Lincoln	Caistor	13				50
	Gainsborough	1				2
Middlesex	Nissouri West					3
Norfolk	Charlotteville	1				14
	Houghton	3				2
	Middleton			2	273,000	17
	Walsingham N.			2	126,000	6
	Walsingham S.			1	18,000	15
	Windham					5
	Woodhouse	4		3	245,000	63
Welland	Bertie	6		8	2,860,000	97
	Crowland			3	325,000	50
	Humberstone	5				118
	Wainfleet	1				55
	Willoughby	4	1			51
Wentworth	Binbrook	2	3	6	197,000	71
	Barton					2
	Beverley		1			
	Flamboro West		1			
	Glanford	3	1	1	30,000	28
Total		114	21	115	18,716,435	1915

Note:—Gas wells drilled into the gravel beds above the rock are not included. The Table comprises 72 private wells, but no doubt this is short of the total number.

The shortage of money in 1920 certainly had much to do with limiting drilling operations, but the appointment of a Referee under the Natural Gas Conservation Act, 1921, with powers to fix rates had much more to do with encouraging operations in 1921. A number of independent companies who sell their gas to pipeline companies commenced work, one company drilling as many as 15 wells, 14 of which were producers. The real effect of this new legislation will be seen in 1922, as many companies were not ready to start work before cold weather set in, acquiring leases and financing having occupied most of the year.

It is regrettable that the total number of wells in operation in all fields and their rock pressures has not been recorded in past years. If this had been done the life of the old Welland-Haldimand field might have been gauged, but it is impossible to get enough information to predict its future in graph form as has been done with the Kent field (see Figure 3). It will be noted, however, that the number of wells drilled in 1921 is very much less than the number abandoned, and that the open flow of new wells averages 129,000 cu. ft., whereas ten years ago this would have been considered very low.

Without definite facts one can only sound the warning, CONSERVE.

The future of Ontario's gas supply is in new fields. The known fields have more than enough wells draining them at present. More exploration and deeper exploration must be carried out, or there will not be enough gas sold to make it profitable to maintain the long pipelines in Ontario at present. True enough, some deep drilling has been done and results are none too encouraging, but the tests are scattered and very little has been done to correlate the work of the different companies. Thorough survey of the work done in the past, and careful tabulation of the information gained, should be a useful guide in the search for new gas fields. It is hoped that this work may be undertaken in 1922.

The usual amount of drilling was carried out in the old fields excepting the fields in Bruce county and Oil Springs, where the limits of the present fields appear to have been reached.

Mr. Bon Jasperson tested a new field in Essex county with indifferent success.

The Union Natural Gas Company discovered a new deep field in Dawn township after two failures.

The Sarnia Gas and Oil Company has discovered a new gas field in Sarnia township at shallow depth. The wells have only a moderate production.

The Dominion Natural Gas Company has found a new field at Lakeview at the expense of some dry holes.

The Provincial Natural Gas Company has discovered a small body of gas under high pressure at Point Abino on the edge of the almost exhausted Welland field that has been producing gas for 33 years. Unfortunately there is space for only three wells in this small area.

The Valley Oil and Gas Company drilled a well at Dundas with a very small show of gas and oil, and in a second well at Copetown found such deep and difficult surface that the well had to be abandoned at 537 feet. The company is extending its operations in 1922.

Samuel S. Wyer's Report

In the spring of 1921, in view of the conflicting opinions freely expressed regarding the volume of gas remaining in the Kent county gas field—the principal gas area of Ontario—and its bearing on fair and reasonable prices for gas, the government of Ontario decided to have an examination and report made on the same by an impartial and competent expert. It was agreed on all sides that Samuel S. Wyer, consulting engineer of Columbus, Ohio, a recognized authority on natural gas, possessed the requisite qualifications and experience, and he was accordingly commissioned to undertake the task.

The text of Mr. Wyer's Report, in which he deals in an illuminating way with the present and future of the natural gas situation in Kent county, is as follows:—

HON. HENRY MILLS,
Minister of Mines,
Toronto, Ontario.

Dear Sir:

In accordance with your instructions, I have made a personal inspection and analysis of your natural gas situation in the Kent Field in Western Ontario, and find the following:

1—Since 1910, average rock pressure has declined from 570 to 256 pounds.
2—There is no justification whatever for making open flow volume test of wells, because of needless gas waste.
3—The transmission and distribution leakage is excessive, and should be curtailed.
4—The percentage contracts for sale of gas are against public policy, and should be abrogated at once.
5—Meters should be installed to measure gas into and out of all transmission lines.
6—Domestic consumers waste enormous quantities of gas through improper appliances.
7—All gas using appliances should be inspected at once by gas companies.
8—The use of wasteful appliances should be prohibited.
9—All extensions to merely maintain service should be paid for out of operating expense and not capitalized.
10—A just retail price can be fixed only by paying an adequate return on the present fair value of natural gas properties.
11—The immediate carrying out of these recommendations is imperative in order to cope with the cold weather conditions of next winter.

Respectfully submitted,
Samuel S. Wyer.

Columbus, Ohio.
May 31, 1921.

Part I.—Present Natural Gas Situation

(1) *Misleading Nature of Open Flow Data.*—The term "open or natural flow" refers to the entiire volume of gas that will come from the mouth of a gas well when blown directly into the atmosphere and retarded only by atmospheric pressure.

The custom of exploiting original open flow capacities of natural gas wells in "cubic feet" rather than in "M" cubic feet, and without any regard to actual delivering possibilities, alone has led to grossly misleading impressions. Thus for a popular "million cubic foot well":

	In 24 Hours.
Original open flow capacity	1,000,000 cu. ft.
Gas for market is always measured and sold in units of 1,000 cu. ft. Thus in terms of marketing units, this 1,000,000 cu. ft. represents only	1,000 "M" cu. ft.
Because of operating limitations, not more than 25% of the open flow capacity can generally be delivered from the average natural gas well. This reduces the actual marketing units of the "million cu. ft. well" to	250 "M" cu. ft.

The well capacity will decline from the beginning of gas removal until the expiration of the well's life. The rate of decline in the earlier period of the well's life will generally be much more marked than in the latter part. Therefore, the average output of a 1,000,000 cu. ft. well, even under Canada's longer cold weather conditions, will be about .... 140 "M" cu. ft.

(2) *Significance of Rock Pressure.*—When nature generated or deposited the natural gas in the rock reservoir—made up of the microscopic cavities between the sand grains—a fixed amount of gas was placed in a fixed inclosed space. The pressure in the rock—called "rock pressure"—was the result of the pressing into this fixed space of a larger volume of gas than the mere free air capacity of this rock reservoir. The degree of compression employed by nature in the formation process determined the intensity of the resulting pressure in the reservoir.

As the gas is removed, the rock pressure and volume must decline, because there is no regeneration, and only a fixed amount of gas was placed in the reservoir, and if a part of this fixed volume is removed the remaining gas volume expands and keeps the reservoir completely filled——except as water intrusion interferes—but at a lower pressure. Rock pressure decline is, therefore, inevitable whenever any gas is removed, and the average rate of decline for a number of wells is generally a much better index of the amount of gas left than any data pertaining to any relative open flow capacity at different periods.

The rock pressure decline in the past—based on data collected by your department—is shown on the next page, as well as my estimates for future decline under conservation and adequate price operating conditions. The average rock pressure of 260 wells measured in May, 1921, was 256 pounds.

The importance of refinements in rock pressure data have been much exaggerated. The practical problem is how to best use the residue gas that remains. Variations of a few pounds either way are of no consequence now.

The desirability of obtaining rock pressures with surrounding wells shut in has been much over-stressed. Wells are not operated on this basis, and the actual rock pressures determined under average operating conditions are more dependable as an index of the true condition.

(3) *Gas Merely an Incident of Oil Prospecting.*—It is not generally appreciated that natural gas is found primarily as a by-product in the search for oil. This is due to the fact that the oil industry does not have any public utility obligations and can be handled with much less capital than is required for natural gas, and the average prospector would very much prefer to find oil rather than gas.

(4) *No Holding Back of Supply.*—There has not been any holding back of the natural gas supply in the field, as has been alleged. It is, of course, obviously true that where a main pipe line leaves a field to supply a large number of consumers, that the gate valves of the lateral lines close to the field cannot ordinarily be kept wide open if service is to be rendered to all of the towns, because the towns nearest the field would take all of the gas and not leave any for the towns further away.

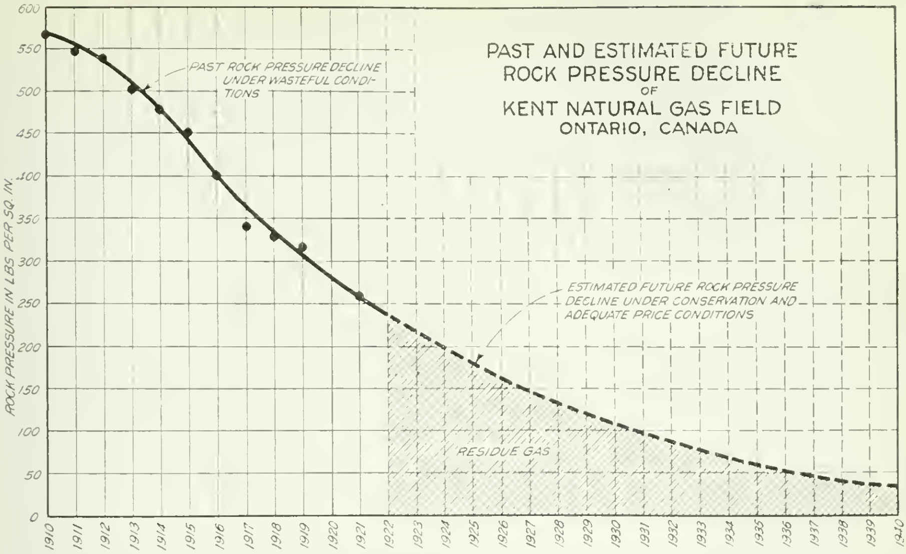
(5) *Water Pumping.*—The intrusion of water in the gas sand makes the field operating conditions especially troublesome. The methods now in use for removing the water with mechanical pumps rather than by blowing wells, are to be commended. This water problem obviously increases the operating costs.

(6) *Sulphur Problem.*—The high sulphur content of the gas gives it an offensive odor, but does not interfere with the heating value of the gas; that is, for heating purposes the gas has the average number of heating units per cubic foot. The offensive odor has some advantages in that it makes the detection of gas leaks very much easier, and the leakage condition with the high sulphur gas should be very much better than the average. This has not been realized in practice due to the negligence in handling the gas.

(7) *Waste in Production.*—Much gas has been needlessly wasted in unnecessary well blowing. There can be no justification whatever for blowing wells merely to determine the open flow capacity, because the rock pressure decline data, which can be secured without any waste of gas, give a much better index of the future serving possibilities. This is such a serious matter that your department should prohibit open flow blowing except where it is necessary to test wells for water conditions.

Many of the gate valves in the field are leaking badly, and there is much gas lost along the field lines and around the rural consumers' premises.

(8) *Waste in Transmission.*—Due to the lack of measuring data in the field, there is no definite check as to the amount of gas put into the transmission lines. Meters should be installed, not at each individual well, but at groups of wells, so as to get a definite basis of measurement of the amount of gas delivered to the transmission lines.



(9) *Waste in Distribution.*—The waste in distribution is excessively high. Much of the gas is sold through percentage contracts; that is, where the natural gas is delivered to the local distributing plant and then sold to the local distributing company on the basis of a certain percentage of the income from the ultimate consumers' meters, without any definite limitation as to leakage conditions of the local distributing company's plant, through which the gas must be passed to be marketed or delivered to the ultimate consumer. These percentage contracts should be abrogated at once, for the reasons given in Section 14.

The leakage should be reported in terms of "1,000" cu. ft., of gas lost per annum per mile of equivalent 3-inch pipe.[1]

The criminal waste in some of the distributing plants is obvious from the following comparison:

	Annual Unaccounted for Gas Per Mile 3-Inch Pipe in "1,000" Cu. Ft.
Good manufactured gas practice	100
Ohio Fuel Supply Co.'s own distributing plants in Ohio, aggregating 60,000 consumers	190
Standard fixed by United States District Court[2] of Kansas, December 22, 1920, as attainable	200
Sarnia, Ontario Distributing plant	590
Chatham, Ontario distributing plant	4,800
Wallaceburg, Ontario distributing plant	4,900

The distributing pressures carried are higher than desirable for good service. See Section 20.

(10) *Waste in Natural Gas Use.*—Due to poor appliances, the average domestic consumer wastes much more gas than he uses. Much gas is wasted in leakage, improper combustion, and burning of gas for a longer period than is necessary. The use of gas in coal burning appliances is always grossly wasteful, and natural gas should be used only in appliances designed especially for gas. The waste in hot water tank heating and in cooking is exceptionally large, as is shown by the abnormally high consumption of gas in hot summer months when the heating load is off.[3]

(11) *Why Natural Gas Supply is Short.*—The demand is now greater than the available supply. The supply will become less each year and cannot be increased. The demand must be curtailed to meet the constantly decreasing supply available.

---

[1] Sizes other than 3-inch are converted to 3-inch by multiplying by the ratio of the respective diameters. That is, one mile of 6-inch would be equivalent to two miles of 3-inch, and one mile of 1½-inch would be equivalent to one-half mile of 3-inch.

[2] 269 Federal Reporter, p. 433.

[3] For further discussion see Technical Paper 257 "Waste and correct use of natural gas in the home." United States Bureau of Mines, Washington, D.C.

The leakage in the field in transmission and distribution is excessive and must be curtailed, if continuity of service for the future is to be secured.

The consumers' methods for use of gas in the home are grossly wasteful. With efficient use the same service can be secured with a very much smaller volume. The peak load demand in winter time for heating load fluctuates with the temperature, that is, as the temperature goes down the demand for gas increases very rapidly, and during low temperature periods this demand is greater than the serving possibilities of the supply. For this reason, not only must efficient appliances be used, but the heating load must be rapidly curtailed.

Part II.—How To Keep Natural Gas Industry Alive

(12) *Natural Gas Industry Has Reached Crisis.*—Your natural gas industry reached the peak of its production in 1917, and has declined since that date. It is now in a rapid transition stage, and unless immediate steps are taken to bring about a complete re-organization of the methods of production, transmission and use, the industry can live for but a very few years. The only way the industry can be made to continue to function is to place it on a conservation basis. That is, curtail waste in production transmission, distribution and use. If the facts are faced fairly, squarely and immediately, a solution can be worked out which will produce satisfactory natural gas service for many years. If the facts are not met immediately, then early liquidation of the industry is inevitable. Speed in applying remedial measures is therefore the essence of the present situation.

As to what per cent. of the total residue gas can be saved will depend on the price. That is an adequate price is the crux of the gas conservation question. Furthermore, the important feature now is not to bother with what has happened in the past, but to handle the residue supplies still available in the most efficient manner.

(13) *Substitutes for Natural Gas.*—Natural gas is the ideal fuel for domestic purposes and should be saved for this service. The value of natural gas will be best appreciated by comparing it with the quantities of substitutes required to furnish the same heating energy.

	Amount required to equal "1,000" cu. ft. natural gas.
Manufactured gas	2 "M" cu. ft.
Acetylene	200 lbs. calcium carbide.
Gasoline	8 Imperial Gallons.
Kerosene	7 Imperial Gallons.
Alcohol	12 Imperial Gallons.
Electricity	322 K.W. Hours.

In tests made in the Department of Home Economics, The Ohio State University, Columbus, Ohio, it was shown that $1.00 natural gas, used under low pressure conditions with properly directed short flames, was cheaper than any other fuel that could be secured.[1]

(14) *Percentage Contracts Must Be Eliminated.*—The vicious features of the percentage contract are not in the fact that the gas is sold by the local distributing company on a mere percentage of the total receipts through the ultimate consumers' meters, but in the fact that the wholesale company must first stand all of the leakage in the local distributing plant, and, secondly, that this places no incentive whatsoever on the local distributing company to keep its plant tight, and is the major reason for the deplorable leakage conditions that now exist in distributing plants selling natural gas on a percentage basis. That is, because of these percentage contracts a premium is actually placed on inefficient operation, and the local distributing plant is so operated as to actually stimulate a wanton waste of a limited natural resource, and in so doing greatly injures the public.

Where percentage contracts are in use the following invariably will happen:

a—Collections by the local distributing company will not be as carefully looked after as when the local distributing company is entirely responsible for and the sole loser of unpaid bills.

---

[1] For further discussion see "Kitchen tests of relative cost of natural gas, soft coal, coal oil, gasoline and electricity for cooking" made by the Department of Home Economics, The Ohio State University, Columbus, O., June, 1917.

b—The waste in leakage will always be much greater than where there is a definite responsibility. Most natural gas distributors fail to appreciate that constant vigilance is the price of a tight natural gas plant, and if they are not responsible for the tightness of their plant little or no vigilance will be exercised in curtailing leakage.

Much has been said about the sacredness of contracts, without appreciating that there can be no vested right to do a moral wrong. These percentage contracts are not private contracts, but are public contracts in which the public has a vital interest, and when one recklessly, defiantly, persistently and continuously wastes natural gas, and boldly declares his purpose to continue to do so, he ought not to complain of being branded as the enemy of mankind.

The distributing and wholesale companies should be given two weeks in which to abrogate these objectionable percentage contracts and if they do not agree, then a governmental agency should step in immediately and declare that the contracts are against public policy and should void them in the interest of the public.

(15) *Gas Must Be Measured.*—The status of the large volume high pressure gas measuring art is such that there is no longer any excuse for not using large volume meters where needed. The gas should be measured in the field, not at individual wells but in groups of wells, so as to get a definite basis as to the amount of gas that is put into the line.

All gas removed from the transmission line into lateral lines or town distributing plants should also be measured at the point of removal, so as to give a definite check on the loss in the distributing plant, as well as in the main or lateral line back to the field measurement. The annual figures obtained should be made public so that the relative efficiencies of the different lines could be noted, and all distributing plant leakage should be reported in terms of "1,000" cu. ft. of gas lost per annum per mile of 3-inch main.

(16) *Gas Leakage Must Be Curtailed.*—Considerable money must be spent in correcting the leakage conditions now prevailing, not only in the main lines but also in the distributing plants, and the hunting and locating of leaks must be regarded as a continuous task.

(17) *Wasteful Appliances Must Be Eliminated.*—The Ontario Government should issue rules that would prohibit the use of wasteful appliances in the home. Where one consumer wastes gas, even though he may pay for the waste, he at the same time destroys that which his neighbor has need of and interferes with the service to his neighbor, and the question of home waste is therefore a matter in which the community interest is paramount.[1]

(18) *Appliances Should Be Inspected.*—Arrangements should be made at once for the gas companies to have competent men inspect all natural gas using appliances, and show the consumer what changes would be necessary in order to bring about correct use of gas.[2]

(19) *Future Extensions for Maintaining Service Should Not Be Capitalized.*—Extensions in the way of additional drilling operations, field lines or remedial measurers to curtail leakage, should not be capitalized, but should be wiped out in the operating account each year. Such expenditures are merely made to maintain continuity of service and the capital account should not be increased. In cases where the extensions could not all be wiped out in one year they should be amortized within two or three years, but never charged to capital.

(20) *Pressures must be lowered.*—The distributing plant pressures carried are too high for good service. Lowering of the pressures and properly adjusted appliances will not only greatly curtail the leakage in the distributing plant, but will also improve the operating conditions in the home. That is, pressures in the neighborhood of from one to two ounces will give much better service than pressures in the neighborhood of four ounces.[3]

---

[1] For further discussion *see* Amicus Curiæ report on "Can preventable waste of natural gas in home be prohibited by rules authorized by public service commissions?" Prepared for The Public Service Commission of the Commonwealth of Pennsylvania, Harrisburg, Pa., April 2, 1921.

[2] For further discussion see Resolutions adopted by National Committee on Natural Gas Conservation, promulgated by the United States Bureau of Mines, Washington, D.C., June 11, 1920.

[3] For further discussion of low pressure see Ohio State University Bulletin No. 28, on Effect of gas pressure on natural gas cooking operations in the home.

(21) *Competition in Field Should Be Eliminated.*—The entire field should be operated as a unit, so as to carry uniform pressures as the rock pressures go down.

(22) *Industrial Gas.*—If the field is operated on a conservation basis, then industrial gas sales can be eliminated and the gas saved for the future. While the selling of industrial gas during summer time has depleted the volume available for future use, it has also kept the average domestic price down. To eliminate industrial sales and save the gas for future service must, from the very nature of the case, result in a higher domestic price.

(23) *Conservation and Price.*—I do not believe that there should be a rate increase without proper provision for conservation of the residue supplies. I also know, as a positive fact, that there can be no conservation of residue supplies without an adequate price. The development necessary to get the residue supplies cannot be coerced, but must be induced by an adequate compensatory rate.

Even if every commodity price goes down in the next five years natural gas prices must go up, not because of any economic law of supply and demand, but because only adequate prices will keep the industry functioning for the future, and without such functioning in making natural gas worth saving, natural gas consumers must very shortly in the larger towns go back to manufactured gas, which will have a cost equivalent of at least $2.50 for natural gas, and the smaller towns will be without any gas at all, because manufactured gas plants cannot be maintained in small towns.

Everything that should be done to distribute and use natural gas as it ought to be used must be done to use manufactured gas at all, and if this is done at once, by both the gas companies and the public, no manufactured gas need be used for many years. The magnitude of the retail price will, therefore, determine the degree of conservation that is expedient or possible.

(24) *Determination of Fair Price for Natural Gas.*—This requires the determination of the following four factors:

A—Present fair value of property used and useful in rendering public utility service. The representatives of the companies and the public ought to be able to agree on this figure without going to the expense of any more appraisal work, which, in my judgment, is entirely unnecessary.

B—Operating cost, including taxes and extensions necessary to maintain service.

C—Rate of return on fair present value. This must provide for:

a—Expenditures made or liabilities accrued in the form of a sinking fund, or replacements to maintain the integrity of the property value.

b—Legal rate of interest. Money has just as definite and tangible a cost as a piece of pipe, and this must be ultimately reckoned with—although frequently ignored in all business enterprises.

c—Profit commensurate with the hazard of the enterprise. There is no profit in the enterprise until the above three factors have been provided for, notwithstanding the fact that normal interest rate is frequently confused with profit. The interest for the use of the money included in "b" above is merely the money paid for the use of capital, while profits have their source in the business ability, skill and foresight of the management—as well as in the risks assumed—and are entirely separate and distinct from, and in addition to the amount of money paid for the use of capital.

D—Volume of gas that can be sold through ultimate consumers' meters in the future.

The foregoing operating cost "B" plus the product of the rate of return into the fair value of the property will give the total income needed. This total income divided by item "D" will give the average fair price of gas per "M" to the ultimate consumer.

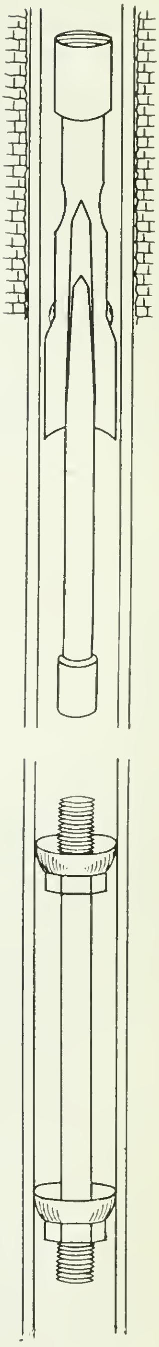
A New Bailing Machine

The bailing machine shown in the photograph has been designed for removing water from wells that have no tubing and can no longer be cleared of water by "blowing" (that is, shutting in the well until the pressure has increased sufficiently to carry the water out with the gas when the head of the well has been opened up). This practice of "blowing" wells is a vicious waste of gas, and has been forbidden by regulation under the Natural Gas Conservation Act, 1921.

A.—Bailing Machine.

Photograph and information through the kindness of Mr. Chas. Beam of the Dominion Natural Gas Company, Dunnville.

B.—Diagram showing tubing holder (top) which screws into packer (bottom) for renewing leaky tubing in low pressure gas wells.



B.

However, a gas well that has so little pressure left that it will not clear itself of water is of very little value, and probably not worth the cost of installing and operating a pump. The bailing machine will keep it "alive" for perhaps several years after it would otherwise have been plugged.

The machine consists of a gasoline engine and a winding drum mounted on an ordinary steel wagon frame. The mast is made of two lengths of casing that telescope inside one another. It is pivoted about one-third of the way up and can be lowered to rest in a seat at the front of the machine. This machine will raise a 4-inch bailer 22 feet long at the rate of 340 feet per minute with the engine running at a moderate speed. A 2-inch bailer in 3-inch casing or tubing can be used, and no doubt a bailer can be run in 2-inch tubing. This machine can also be used to pull $^3/_4$-inch pipe or a pump. It should be of special interest to owners of "private" wells.

Another very useful invention is credited to Ernest Lindsay of the Dominion Natural Gas Company. It is designed for use in the sort of well described, but its use is for renewing tubing. *See* diagram "B," page 35.

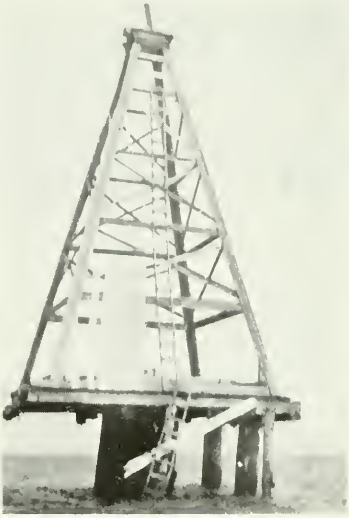
When the tubing above the packer is surrounded by water and has developed a leak near the top, heretofore it has been necessary for the tubing to be pulled out and renewed, but in the meantime enough water would have run in to the gas "sand" to require pumping or syphoning for several days, and in fact many wells if once flooded cannot be recovered. The use of this tool allows the damaged portion of the tubing to be taken out and renewed, without disturbing the packer, the tool being removed without allowing any water to reach the gas "sand."

Mr. Lindsay describes the method used as follows:—

Taking a particular case where the tubing is leaking 60 feet below the top of the casing head, 70 or 80 feet of the $^3/_4$-inch syphon pipe is pulled out and the plunger with the leather cup screwed into the $^3/_4$-inch pipe. On top of this is screwed the tool shown in the cut which holds the tubing from turning. On top of this again is screwed enough inch pipe to allow the $^3/_4$-inch pipe to rest on the bottom. The weight of the inch pipe forces the tapered part of the holder into the lower split portion or jaws made of steel, causing it to expand, the corners engaging the inside of the tubing and holding it fast. A wrench is put on the one-inch pipe at the surface to hold the tubing steady and another wrench is used for unscrewing the tubing in the usual way. It practically always comes apart at the joint immediately above where it is held. The faulty tubing is replaced by sound tubing and put back in the well in the usual way.

Gas Wells in Lake Erie

The photo shows one of the wells drilled in Lake Erie, off shore and opposite Port Alma. Storms break over the floor of the derrick, and ice batters and shoves against this slim column in winter. There is no doubt that the action of ice has diverted the column from the perpendicular, as the piling has been torn away on the shore side. One well head at least in Lake Erie has been entirely swept away through the action of ice, and in such a case the lake water flows freely down into the well, floods the gas sand and ultimately ruins the gas field. Wells drilled in Lake Erie should have more protection than is shown in this photograph.



One of the gas wells in Lake Erie near Port Alma, Tilbury East. An attempt to reach the rickety ladder from a row-boat impresses one with the difficulty and danger of well-drilling in Lake Erie. Note the destruction of piling by an ice shove.

General

An attempt is being made to keep abreast with all developments of the natural gas industry, from the gas wells to the burners. Catalogues are received in the Commissioner's office from all makers of drilling equipment as they are published. A complete set of pamphlets issued by the United States Bureau of Mines on latest methods of field work and treatment of troubles met with in various phases of the industry, as well as many professional papers on the geology of the various States, may be consulted by those interested, also data on the use of the rotary core barrel bit and the development of the diamond drill for use in oil and gas fields.

A study has been made of the latest uses of fuels for manufacturing, and the progress made in utilizing our growing resources of electricity for heating metals and ovens. Catalogues and literature are on hand for reference.

Such records as can be had from drill cuttings taken from gas and oil wells are carefully tabulated, in the hope that they will assist in interpreting the stratigraphy of that part of the Province in which the sedimentary rocks occur.

Locating Gas Leak with Match

The photo shows what remains of a house where a lighted match was used to find a leak in the gas fixtures. The house was filled with gas when the match was lighted.

The result of searching for a gas leak with a match or lamp. Note that only the brick basement of the building remains.

Drillers' Logs

The following logs of wells drilled in 1921 are published as given by the drillers. It will be noted that different drillers use different nomenclature, which is apt to be confusing, but it is hoped that during the year 1922 logs will be collected and shown in the form of cross-sections through the Province, in which form they will be much easier to visualise.

Log No 1; Information by John Stroup, Merlin

Lot.	Concession.	Township	County
11	Middle Road South	Tilbury East	Kent

Estimated production: 70,000. Completed: Oct. 29th, 1921.

Formation.	Thickness of Formation	Total Depth
Drift Clay	147 Feet	147 Feet
Soap	15 "	162 "
Upper Lime	18 "	180 "
Soap	45 "	225 "
Shell	4 "	229 "
Lime	207 "	436 "
Sharp Sand	140 "	576 "
Lime	678 "	1,254 "
Brown Lime	109 "	1,363 "
Total Depth	1,363 ft.	

Log No. 2; Information by A. E. Randall, Petrolia.

Lot.	Concession.	Township.	County.
1	1	Raleigh	Kent.

Estimated Production: (oil) Dry Hole. Completed May 30th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	81 Feet	81 Feet
Soap	28 “	109 “
Lime	4 “	113 “
Soap	25 “	138 “
Lime	8 “	146 “
Soap	2 “	148 “
Lime	7 “	155 “
Soap	31 “	186 “
Big Lime	146 “	332 “
Total Depth	332 Feet.	

Log No. 3; Information by A. E. Randall, Petrolia.

Lot.	Concession.	Township.	County.
1	1	Raleigh.	Kent.

Estimated Production: (oil) Dry Hole. Completed June 18th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	85 Feet.	85 Feet
Sand	10 “	95 “
Soap	20 “	115 “
Lime	4 “	119 “
Soap	21 “	140 “
Lime	8 “	148 “
Soap	2 “	150 “
Lime	10 “	160 “
Soap	31 “	191 “
Big Lime	103 “	294 “
Total Depth	294 Feet.	

Log No. 4; Information by A. Humber, Ruthven.

Lot.	Concession.	Township.	County.
1	1	Raleigh	Kent.

Estimated Production: (oil) 8 bbls. Completed: June 25th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	85 Feet	85 Feet
Soap	56 “	141 “
Lime	8 “	149 “
Soap	31½“	180½“
Big Lime	78½“	259 “
Total Depth	259 Feet.	Oil at 250. Feet.

Log No. 5; Information by A. Humber, Ruthven.

Lot.	Concession.	Township.	County.
1	1	Raleigh	Kent.

Estimated production: (oil) Dry Hole. Completed: July 27th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	82 Feet	82 Feet
Soap	27 “	109 “
Shale	2 “	111 “
Soap	21 “	132 “
Shale	23 “	155 “
Soap	27 “	182 “
Shale	3 “	185 “
Big Lime	75 “	260 “
Total Depth	260 Feet.	

Log No. 6; Information by E. Wolfe, Woodslea.

Lot.	Concession.	Township.	County.
1	1	Raleigh.	Kent.

Estimated production: (oil) Pumped 50 bbls. first 48 hrs. Completed July 27th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	75 Feet	75 Feet
Sand	10 “	85 “
Soap	16 “	101 “
Lime	2 “	103 “
Soap	38 “	141 “
Lime	4 “	145 “
Soap	31½ “	176½ “
Big Lime	101½ “	278 “
Total Depth	278 Feet.	Oil at 209 Feet. Oil at 245 Feet.

Log No. 7; Information by E. Wolfe. Woodlea.

Lot.	Concession.	Township.	County.
1	1	Raleigh.	Kent.

Estimated production: (oil) Pumped 10 bbls. in 12 hrs. Completed June 28th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	81 Feet	81 Feet
Sand	10 “	91 “
Soap	47 “	138 “
Lime	10 “	148 “
Soap	31 “	179 “
Big Lime	107 “	286 “
Total Depth	286 Feet.	Oil at 148 Feet. Oil at 250 Feet.

LOG NO. 8; INFORMATION BY E. WOLFE, WOODSLEA.

Lot.	Concession.	Township.	County.
1	1	Raleigh.	Kent.

Estimated production: (oil) Pumped 5 bbls. in 12 hrs. Completed July 21st, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	81 Feet	81 Feet
Soap	19 "	100 "
Shale	2½ "	102½"
Soap	2 "	104½"
Shale	½"	105 "
Soap	27 "	132 "
Lime	13 "	145 "
Soap	31 "	176 "
Big Lime	115 "	291 "
Total Depth	291 Feet.	Oil at 145 Feet. Oil at 177½ Feet. Oil at 246 Feet.

LOG NO. 9; INFORMATION BY UNION NAT. GAS CO., CHATHAM.

Lot.	Concession.	Township.	County.
10	11	Tilbury East	Kent.

Estimated production: 124,700 cu. ft. Completed Oct. 5th, 1921

Formation.	Thickness of Formation.	Total Depth.
Surface	155 Feet	155 Feet
Soap	61 "	216 "
Lime	274 "	590 "
Sharp Sand	210 "	700 "
Lime	410 "	1,110 "
Gas Sand	298 "	1,408 "
Total Depth	1,408 Feet.	Gas at 1,340 Feet. Gas at 1,376 Feet. Water at 375 Feet. Water at 700 Feet.

LOG NO. 10; INFORMATION BY UNION NAT. GAS CO., CHATHAM

Lot.	Concession.	Township.	County.
11	11	Tilbury East	Kent.

Estimated production: 284,000 cu. ft. Completed Sept. 4th, 1921

Formation.	Thickness of Formation.	Total Depth.
Surface	150 Feet	150 Feet
Soap	45 "	195 "
Lime	305 "	500 "
Sharp sand	220 "	720 "
Brown lime	30 "	750 "
Lime	425 "	1,175 "
Gas sand	218 "	1,393 "
Total Depth	1,393 Feet.	

Water at 350 and 700 feet. Gas at 1,211, 1,330, 1,350 and 1,375 feet

LOG NO. 11; INFORMATION BY UNION NATURAL GAS CO., CHATHAM.

Lot.	Concession.	Township.	County.
13	14	Tilbury East	Kent.

Estimated production: 284,000 cu. ft. Completed Aug. 3rd, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	162 Feet.	162 Feet
Soap	14 "	176 "
Lime	1,004 "	1,180 "
Gas Sand	201 "	1,381 "
Total Depth	1,381 Feet.	

Gas at 1,200 and 1,250 feet. Water at 625 feet.

LOG NO. 12; INFORMATION BY UNION NATURAL GAS CO., CHATHAM.

Lot.	Concession.	Township.	County.
12	Middle Road South.	Tilbury East.	Kent.

Estimated production: open flow very light, well abandoned. Completed Dec. 10th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	155 Feet	155 Feet
Soap	43 "	198 "
Lime	282 "	480 "
Sharp Sand	220 "	700 "
Lime	530 "	1,230 "
Gas Sand	150 "	1,380 "
Total Depth	1,380 Feet	

Gas at 1,325 and 1,377 feet. Water at 465 and 1,330 feet.

LOG NO. 13; INFORMATION BY UNION NATURAL GAS CO., CHATHAM.

Lot.	Concession.	Township.	County.
12	Middle Road South	Tilbury East	Kent.

Estimated production: 373,100 cu. feet. Completed July 29th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	147 Feet	147 Feet
Soap	45 "	192 "
Lime	298 "	490 "
Sharp Sand	190 "	680 "
Lime	500 "	1,180 "
Gas Sand	163 "	1,343 "
Total Depth	1,343 Feet.	

Gas at 1,185, 1,285 and 1,310 feet. Water at 335 and 670 feet.

Log No. 14; Information by Union Natural Gas Co., Chatham.

Lot.	Concession.	Township.	County.
12	Middle Road South.	Tilbury East	Kent.

Estimated production: 781,000 cu. ft. Completed June 10th, 1921.
Rock pressure: 293 lbs.

Formation.	Thickness of Formation.	Total Depth.
Surface	145 Feet	145 Feet
Soap	40 “	185 “
Lime	340 “	555 “
Sharp Sand	190 “	745 “
Lime	465 “	1,180 “
Gas Sand	161 “	1,341 “
Total Depth	1,341 Feet.	

Gas at 1,180 and 1,305 feet. Water at 330 feet.

Log No. 15; Information by Union Natural Gas Co., Chatham.

Lot.	Concession.	Township.	County.
12	Middle Road South.	Tilbury East	Kent.

Estimated production: 1,840,000 cu. ft. Completed April 22nd, 1921.
Rock pressure: 310 lbs.

Formation.	Thickness of Formation.	Total Depth.
Surface	145 Feet	145 Feet
Soap	40 “	185 “
Lime	205 “	390 “
Sharp Sand	160 “	550 “
Lime	490 “	1,140 “
Gas Sand	206 “	1,346 “
Total Depth	1,346 Feet.	

Gas at 1,160 and 1,265 feet. Water at 145 feet

Log No. 16; Information by Union Natural Gas Co., Chatham.

Lot.	Concession.	Township.	County.
10	10	Tilbury East.	Kent.

Estimated production: 325,000 cu. ft. Completed Nov. 23rd, 1921.
Rock pressure: 310 lbs.

Formation.	Thickness of Formation.	Total Depth.
Surface	151 Feet	151 Feet
Soap	38 “	189 “
Lime	281 “	470 “
Sharp Sand	670 “	1,140 “
Gas Sand	249 “	1,389 “
Total Depth	1,389 Feet.	

Gas at 1,200, 1,290 and 1,330 feet. Water at 678 feet

Log No. 17; Information by John Stroup, Merlin.

Lot.	Concession.	Township.	County.
13	Middle Road South.	Tilbury East.	Kent.

Estimated production: 1,000,000 cu. ft. Completed June 9th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	130 Feet	130 Feet
Shale	17 “	147 Feet
Soap	18 “	165 “
Gray Lime	865 “	1,030 “
Lime and Slate	145 “	1,175 “
Gray Lime	143 “	1,318 “
Total Depth	1,318 Feet.	

Log No. 18; Information by John Stroup, Merlin.

Lot.	Concession.	Township.	County.
13	12	Tilbury East.	Kent.

Estimated production: 85,000 cu. ft. Completed Sept. 12th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Drift Clay	145 Feet	145 Feet
Soap	40 “	185 “
Big Lime	140 “	325 “
Dark Lime	250 “	575 “
Sharp Sand	65 “	640 “
Lime	744 “	1384 “
Total Depth	1,384 Feet.	

Log No. 19; Information by E. P. Rowe. Toronto.

Lot.	Concession.	Township.	County.
1	1	Dover.	Kent.

Estimated production: 80,000. Completed May, 1921.
Rock pressure: 900 lbs.

Formation.	Thickness of Formation.	Total Depth.
Surface	97 Feet	97 Feet
Shale Top Rock	6 “	103 “
Upper Soap Hamilton	115 “	218 “
Middle Lime	15 “	233 “
Lower Soap	68 “	301 “
Onondaga	1,290 “	1,591 “
Niagara	350 “	1,941 “
Niagara Shale, Dark	51 “	1,992 “
Red Shale	50 “	2,042 “
Grey Shale	30 “	2,072 “
Clinton Lime and Dolomite	70 “	2,142 “
Red Shale, Medina	60 “	2,202 “
White Medina	20 “	2,222 “
Red Medina	280 “	2,502 “
Hudson River	291 “	2,793 “
Utica, brown and black	114 “	2,907 “
Trenton	398 “	3,305 “
Total Depth	3,305 Feet.	

Gas at 2,927, 3,025, 3,075 and 3,105 feet. Small show of oil.

LOG NO. 20; INFORMATION BY W. J. HUSSEY, PETROLIA.

Lot. 4	Concession.	Township.	County.
J. A. Ferguson farm.	2	Raleigh.	Kent.

Dry Hole.

Formation.	Thickness of Formation.	Total Depth.
Surface	70 Feet	70 Feet
Gravel	15 "	85 "
Shale	50 "	135 "
Top Soap	95 "	230 "
Middle Lime	18 "	248 "
Lower Soap	52 "	300 "
Lower Lime	200 "	500 "
Total Depth	500 Feet.	

LOG NO. 21; INFORMATION BY W. J. HUSSEY, PETROLIA.

Lot.	Concession.	Township.	County.
4	2	Raleigh.	Kent.

Dry Hole.

Formation.	Thickness of Formation.	Total Depth.
Surface	51 Feet	51 Feet
Gravel and Sand	15 "	66 "
Top Rock	30 "	96 "
Top Soap	130 "	226 "
Middle Lime	12 "	238 "
Lower Soap	24 "	262 "
Lower Lime	138 "	400 "
Total Depth	400 Feet.	

LOG NO. 22; INFORMATION BY STOVER DRILLING CO., CHATHAM.

Lot.	Concession.	Township.	County.
11	4	Dover E.	Kent.

Open flow: 10,000 cu. ft.
Oil: 5 bbls. per day.

Completed Dec. 9th, 1920.

Formation.	Thickness of Formation.	Total Depth.
Surface	75 Feet	75 Feet
Black Shale	28 "	103 "
Soapstone and Limestone	200 "	303 "
Corniferous Limestone	102 "	405 "
Sylvania Limestone	70 "	475 "
Onondaga Limestone and Dolomite	885 "	1,360 "
Onondaga Limestone and Rock Salt	110 "	1,470 "
Guelph Dolomite	215 "	1,685 "
Niagara Limestone	267 "	1,952 "
Niagara Shale	15 "	1,967 "
Clinton Sandstone	25 "	1,992 "
Red Shale	58 "	2,050 "
Grey Shale	80 "	2,130 "
White Medina	5 "	2,135 "
Red Medina Shale	105 "	2,240 "
Hudson River Limestone and Shale	485 "	2,725 "
Utica Shale	173 "	2,898 "
Trenton Limestone	434 "	3,332 "
Total Depth	3,332 Feet.	

LOG NO. 23; INFORMATION BY JOHN STROUP, MERLIN.

Lot.	Concession.	Township.	County.
11	Middle Road South.	Tilbury E.	Kent.

Open flow: 120,000 cu. ft.
Rock pressure: 290 lbs.

Completed Dec. 14th, 1921.

Formation.	Thickness of Formation.	Total Depth
Clay	128 Feet	128 Feet
Quick Sand	17 “	145 “
Shale	5 “	150 “
Soap	22 “	172 “
Lime	38 “	210 “
Lime	230 “	440 “
Sharp Sand	80 “	520 “
Lime	834 “	1,354 “
Total Depth	1,354 Feet	

LOG NO. 24; INFORMATION BY AJAX OIL AND GAS CO., TORONTO.

Lot.	Concession.	Township.	County.
2	1	Raleigh.	Kent.

Completed January, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	60 Feet	60 Feet
Quick Sand	42 “	102 “
Soap	14 “	116 “
Hard Lime	8 “	124 “
Soft Soap	18 “	142 “
Soft Lime	8 “	150 “
Hard Lime	15 “	165 “
Soap	27 “	192 “
Hard Lime	88 “	280 “
Soft Lime	18 “	298 “
Total Depth	298 Feet.	

Oil at 210, 235, 265 and 280 feet.

LOG NO. 25; INFORMATION BY GEO. D. BROWN, CHATHAM.

Lot.	Concession.	Township.	County.
2	2 & 3	Raleigh.	Kent.

Completed Feb. 19th, 1921.

Formation	Thickness of Formation.	Total Depth.
Clay	65 Feet	65 Feet
Sand	36 “	101 “
Soap	27 “	128 “
Middle Lime	7 “	135 “
Soap	35 “	170 “
Lower Soap	35 “	205 “
Lower Lime	95 “	300 “
Total Depth	300 Feet.	

Oil at 130 feet.

Gas at 208 feet.

Log No. 26; Information by Geo. D. Brown, Chatham.

Lot.	Concession.	Township.	County.
2	2 and 3	Raleigh	Kent.

Completed March 22nd, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	70 Feet	70 Feet
Sand	31 "	101 "
Soap	19 "	120 "
Lime	7 "	127 "
Soap	13 "	140 "
Lime	1 "	141 "
Soap	6 "	147 "
Lime	13 "	160 "
Soap	34 "	194 "
Limestone	109 "	303 "
Total Depth	303 Feet.	

Oil at 232 feet.

Gas at 275 feet

Log No. 27; Information by A. E. Randall, Petrolia.

Lot.	Concession.	Township.	County.
2	2 and 3	Raleigh.	Kent.

Completed Dec. 3rd, 1921.

Formation.	Thickness of Formation.	Total Depth.
Subsoil	10 Feet	10 Feet
Clay	24 "	34 "
Sand and Gravel	4 "	38 "
Clay	32 "	70 "
Sandy Clay	22 "	92 "
Soap	15 "	107 "
Lime	4 "	111 "
Soap	1 "	112 "
Lime	2 "	114 "
Soap	26 "	140 "
Lime	5 "	145 "
Soap	5 "	150 "
Middle Lime	6 "	156 "
Lower Lime	29 "	185 "
Lower Lime	105 "	290 "
Total Depth	290 "	

Oil at 190 feet.

Log No. 28; Information by A. E. Randall, Petrolia.

Lot.	Concession.	Township.	County.
2	2 and 3.	Raleigh.	Kent.

Completed Dec. 28th, 1922.

Formation.	Thickness of Formation.	Total Depth.
Subsoil	8 Feet	8 Feet
Clay	47 "	55 "
Sandy Clay	15 "	70 "
Soap and Clay	10 "	80 "
Sand	15 "	95 "
Soap	33 "	128 "
Lime	2 "	130 "
Soap	2 "	132 "
Lime	2 "	134 "
Soap	27 "	161 "
Middle Lime	5 "	166 "
Soap	5 "	171 "
Lime	2 "	173 "
Soap	37 "	210 "
Lower Lime	90 "	300 "
Total Depth	300 Feet.	

Oil at 216 feet.

Gas at 262 Feet

Log No. 29; Information by Bon Jasperson, Kingsville.

Lot.	Concession.	Township.	County.
8	1	Gosfield S.	Essex.

Open flow: 17,009 cu. ft.
Rock pressure: 240 lbs.

Completed Nov. 28th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Quick Sand	85 Feet	85 Feet
Grey Lime	416 "	501 "
Brown Lime	189 "	690 "
Grey Lime	60 "	750 "
Slate	90 "	840 "
Lime	60 "	900 "
Lime	130 "	1,030 "
Total Depth	1,030 Feet.	

Log No. 30; Information by Imperial Oil Co.

Lot.	Concession.	Township.	County.
1	1	Mersea.	Essex.

Dry Hole.

Completed February, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	121 Feet	121 Feet
Limestone	744 "	865 "
Limestone	770 "	1,635 "
Red Shale	20 "	1,655 "
Grey Shale	18 "	1,673 "
Red Shale	13 "	1,686 "
Grey Shale	80 "	1,766 "
Grey Lime	26 "	1,792 "
Red Shale	112 "	1,904 "
Grey Shale	52 "	1,956 "
Red Shale	40 "	1,996 "
Grey Shale	480 "	2,476 "
Black and Grey Shale	35 "	2,511 "
Trenton Lime	825 "	3,336 "
Sandstone	10 "	3,346 "
Total Depth	3,346 Feet.	

Log No. 31; Information by Glenwood Company.

Lot.	Concession.	Township.	County.
18	4	Mersea.	Essex.

Open flow: 22,000 cu. ft.
Rock pressure: 300 lbs.

Completed Aug. 5th, 1921

Formation.	Thickness of Formation.	Total Depth.
Clay	75 Feet.	75 Feet
Gray Lime	205 "	280 "
Brown Lime	200 "	480 "
Lime	195 "	675 "
Brown Lime	125 "	800 "
Lime	190 "	990 "
Salt Sand	17 "	1,007 "
Total Depth	1,007 Feet.	

Salt water at 990 feet.

LOG NO. 32; INFORMATION BY UNION EXPLORATION CO., CHATHAM.

Lot.	Concession.	Township.	County.
24	5	Dawn No. 3.	Lambton.

Open flow: 177,400 cu. ft.
Rock pressure: 775 lbs.

Completed November, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	90 Feet	90 Feet
Shale	190 "	280 "
Soap	180 "	460 "
Lime	65 "	525 "
Soap	15 "	540 "
Grey Lime	1,075 "	1,615 "
Clinton	535 "	2,150 "
Total Depth	2,150 Feet.	

Gas at 1,615 and 1,750 feet.

Water at 610 feet

LOG NO. 33; INFORMATION BY JOHN KENNEY, DUNNVILLE.

Lot.	Concession.	Township.	County.
4	7	Crowland.	Welland.

Open flow: 150,000 cu. ft.
Rock pressure: 200 lbs.

Completed Nov. 3rd, 1921.

Formation.	Thickness of Formation.	Total Depth.
Niagara Dolomite	78 Feet	78 Feet
Limestone and Shale	400 "	478 "
Clinton Shale	55 "	533 "
Clinton Lime	37 "	570 "
Red Medina	60 "	630 "
Blye Shale	40 "	670 "
White Medina	15 "	685 "
Red Shale	23 "	708 "
Total Depth	708 Feet.	

Gas at 538, 570-630 and 680 feet.

Water at 450 feet

LOG NO. 34; INFORMATION BY JOHN KENNEY, DUNNVILLE.

Lot.	Concession.	Township.	County.
3	7	Crowland	Welland.

Open flow: 20,000 cu. ft.
Rock pressure: 250 lbs.

Completed Aug. 24th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	100 Feet	100 Feet
Shale	100 "	200 "
Niagara Dolomite	260 "	460 "
Clinton Shale	50 "	510 "
Clinton Lime	32 "	542 "
Red Medina	58 "	600 "
Blue Shale	30 "	630 "
White Medina	15 "	645 "
Red Shale	41 "	686 "
Total Depth	686 Feet.	

Water at 150. Black water at 210 with sulphur gas.

Log No. 35; Information by C. W. Featherstone, Dunnville.

Lot.	Concession.	Township.	County.
10	14	Walpole	Haldimand.

Open flow: 150,000 cu. ft. Completed July 26th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	10 Feet	10 Feet
Flint	50 "	60 "
Lime and Shale	365 "	425 "
Niagara	274 "	699 "
Casing Shale	21 "	720 "
Clinton	33 "	753 "
Red Medina	20 "	773 "
Grey Shale	66 "	839 "
White Medina	12 "	851 "
Red Shale	13 "	864 "

Total Depth 864 Feet.

Log No. 36; Information by C. W. Feathersotne, Dunnville.

Lot.	Concession.	Township.	County.
11	13	Walpole.	Haldimand.

Open flow: 100,000 cu. ft. Completed May 9th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	17 Feet	17 Feet
Lime and Shale	413 "	430 "
Niagara	200 "	630 "
White Lime	70 "	700 "
Shale	26 "	726 "
Clinton	37 "	763 "
Red Medina	24 "	787 "
Gray Shale	56 "	843 "
White Medina	12 "	855 "
Red Shale	5 "	860 "

Total Depth 860 Feet.

Log No. 37; Information by C. W. Featherstone, Dunnville.

Lot.	Concession.	Township.	County.
Part of Young Tract.		Seneca.	Haldimand.

Open flow: 103,000 cu. ft. Completed Aug. 24th, 1921
Rock pressure: 230 lbs.

Formation.	Thickness of Formation.	Total Depth.
Surface	95 Feet	95 Feet
Lime and Shale	100 "	195 "
Niagara	250 "	445 "
Shale	44 "	489 "
Clinton	29 "	518 "
Red Medina	37 "	555 "
Blue Shale	60 "	615 "
White Medina	15 "	630 "
Red Shale	50 "	680 "

Total Depth 680 Feet.
Gas at 494 and 513 feet.

Log No. 38; Information by C. W. Featherstone, Dunnville.

Lot.	Concession.	Township.	County.
Part of Dennis Block.		Oneida.	Haldimand.

Open flow: 58,000 cu. ft.
Rock pressure: 270 lbs.

Completed Sept. 2nd, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	44 Feet	44 Feet
Lime and Shale	150 "	194 "
Niagara	250 "	444 "
Shale	16 "	460 "
Clinton	24 "	484 "
Red Medina	34 "	518 "
Blue Shale	63 "	581 "
White Medina	11 "	592 "
Red Shale	51 "	643 "

Total Depth . . . . 643 Feet.

Gas at 465 and 472 feet.

Log No. 39; Information by C. W. Featherstone, Dunnville.

Lot.	Concession.	Township.	County.
Part of Dennis Block.		Oneida.	Haldimand.

Open flow: 18,000 cu. ft.
Rock pressure: 260 lbs.

Completed Oct. 13th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	46 Feet	46 Feet
Lime and Shale	214 "	260 "
Niagara	259 "	519 "
Shale	22 "	541 "
Clinton	21 "	562 "
Red Medina	37 "	599 "
Blue Shale	53 "	652 "
White Medina	11 "	663 "
Red Shale	50 "	713 "

Total Depth . . . . 713 Feet.

Gas at 543 and 553 feet.

Log No. 40; Information by C. W. Featherstone, Dunnville.

Lot.	Concession.	Township.	County.
Farm of Wm. Bell		Oneida.	Haldimand.

Open flow: 37,000 cu. ft.
Rock pressure: 270 lbs.

Completed Nov. 3rd, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	28 Feet	28 Feet
Lime and Shale	197 "	225 "
Niagara	243 "	468 "
Shale	28 "	496 "
Clinton	26 "	522 "
Red Medina	39 "	561 "
Blue Shale	63 "	624 "
White Medina	12 "	636 "
Red Shale	54 "	690 "

Total Depth . . . . 690 Feet.

Log No. 41; Information by C. W. Featherstone, Dunnville.

Lot.	Concession.	Township.	County.
72 and 73.	River Range.	Oneida.	Haldimand.

Open flow: 111,000 cu. ft.
Rock pressure: 240 lbs.

Completed Nov. 29th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	24 Feet	24 Feet
Lime and Shale	196 “	220 “
Niagara	242 “	462 “
Shale	36 “	498 “
Clinton	22 “	520 “
Red Medina	45 “	565 “
Blue Shale	52 “	617 “
White Medina	12 “	629 “
Red Shale	39 “	668 “
Total Depth	668 Feet.	

Gas at 522-540 feet.

Log No. 42; Information by C. W. Featherstone, Dunnville.

Lot.	Concession.	Township.	County.
64	River Range.	Oneida.	Haldimand.

Open flow: 88,000 cu. ft.
Rock pressure: 310 lbs.

Completed May 17th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	56 Feet	56 Feet
Lime and Shale	179 “	235 “
Niagara	233 “	468 “
Shale	34 “	502 “
Clinton	29 “	531 “
Red Medina	45 “	576 “
Blue Shale	59 “	635 “
White Medina	10 “	645 “
Red Shale	50 “	695 “
Total Depth	695 Feet.	

Gas at 510, 530, 541 and 640 feet.

Log No. 43; Information by C. W. Featherstone, Dunnville.

Lot.	Concession.	Township.	County.
Part of Young Tract.		Seneca.	Haldimand.

Open flow: 58,000 cu. ft.
Rock pressure: 280 lbs.

Completed May 30th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	84 Feet	84 Feet
Lime and Shale	141 “	225 “
Niagara	245 “	470 “
Shale	40 “	510 “
Clinton	25 “	535 “
Red Medina	33 “	568 “
Blue Shale	55 “	623 “
White Medina	25 “	648 “
Red Shale	51 “	699 “
Total Depth	699 Feet.	

Gas at 512 and 569 feet.

LOG NO. 44; INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE.

Lot.	Concession.	Township.	County.
62	River Range.	Oneida.	Haldimand.

Open flow: 105,000 cu. ft.
Rock pressure: 345 lbs.

Completed June 9th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	48 Feet	48 Feet
Lime and Shale	172 "	220 "
Niagara	254 "	474 "
Shale	32 "	506 "
Clinton	28 "	534 "
Red Medina	30 "	564 "
Blue Shale	56 "	620 "
White Medina	10 "	630 "
Red Shale	50 "	680 "

Total Depth................ 680 Feet.
Gas at 508, 516, 531, 549 and 625.

LOG NO. 45; INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE.

Lot.	Concession.	Township.	County.
Part of Young Tract.		Seneca.	Haldimand.

Open flow: 68,000 cu. ft.
Rock pressure: 260 lbs.

Completed June 21st, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	104 Feet	104 Feet
Lime and Shale	114 "	218 "
Niagara	245 "	463 "
Shale	32 "	495 "
Clinton	33 "	528 "
Red Medina	38 "	566 "
Blue Shale	50 "	616 "
White Medina	15 "	631 "
Red Shale	46 "	677 "

Total Depth................ 677 Feet.
Gas at 499 and 530 feet.

LOG NO. 46; INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE.

Lot.	Concession.	Township.	County.
60	River Range.	Oneida.	Haldimand.

Open flow: 97,000 cu. ft.
Rock pressure: 305 lbs.

Completed July 2nd, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	57 Feet	57 Feet
Lime and Shale	171 "	228 "
Niagara	254 "	482 "
Shale	19 "	501 "
Clinton	22 "	523 "
Red Medina	40 "	563 "
Blue Shale	63 "	626 "
White Medina	11 "	637 "
Red Shale	50 "	687 "

Total Depth................ 687 Feet.
Gas at 503, 511, 628 and 636 feet.

LOG NO. 47; INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE.

Lot.	Concession.	Township.	County.
Part of Young Tract.		Seneca.	Haldimand.

Open flow: 37,000 cu. ft.
Rock pressure: 260 lbs.

Completed July 15th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	96 Feet	96 Feet
Lime and Shale	119 "	215 "
Niagara	245 "	460 "
Shale	34 "	494 "
Clinton	30 "	524 "
Red Medina	35 "	559 "
Blue Shale	60 "	619 "
White Medina	21 "	640 "
Red Shale	50 "	690 "

Total Depth .... 690 Feet.
Gas at 499, 519 and 629 feet.

LOG NO. 48; INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE.

Lot.	Concession.	Township.	County.
Farm of C. H. Wills.		Seneca.	Haldimand.

Open flow: 100,000 cu. ft.
Rock Pressure: 230 lbs.

Completed Aug. 10th, 1921

Formation.	Thickness of Formation.	Total Depth.
Surface	102 Feet	102 Feet
Lime and Shale	113 "	215 "
Niagara	245 "	460 "
Shale	39 "	499 "
Clinton	28 "	527 "
Red Medina	35 "	562 "
Blue Shale	55 "	617 "
White Medina	12 "	629 "
Red Shale	50 "	679 "

Total Depth .... 679 Feet.
Gas at 504, 516 and 622 feet.

LOG NO. 49; INFORMATION BY C. W. FEATHERSTONE, DUNNVILLE.

Lot.	Concession.	Township.	County.
59	River Range.	Oneida.	Haldimand.

Open flow: 88,000 cu. ft.
Rock pressure: 270 lbs.

Completed Aug. 11th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	45 Feet	45 Feet
Lime and Shale	150 "	195 "
Niagara Shale	244 "	439 "
Shale	20 "	459 "
Clinton	24 "	483 "
Red Medina	34 "	517 "
Blue Shale	63 "	580 "
White Medina	10 "	590 "
Red Shale	50 "	640 "

Total Depth .... 640 Feet.
Gas at 167, 477 and 582.

Log No. 50; Information by C. W. Featherstone, Dunnville.

Lot.	Concession.	Township.	County.
14	River Range.	Seneca.	Haldimand.

Open flow: 55,000 cu. ft.
Rock pressure: 230 lbs.

Completed Jan. 25th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	43 Feet	43 Feet
Lime and Shale	147 "	190 "
Niagara	242 "	432 "
Shale	38 "	470 "
Clinton	27 "	497 "
Red Medina	38 "	535 "
Blue Shale	58 "	593 "
White Medina	11 "	604 "
Red Shale	50 "	654 "

Total Depth.............. 654 Feet.

Gas at 480, 507 and 598 feet.

Log No. 51; Information by C. W. Featherstone, Dunnville.

Lot.	Concession.	Township.	County.
14	River Range.	Seneca.	Haldimand.

Open flow: 111,000 cu. ft.
Rock pressure: 240 lbs.

Completed Feb. 19th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	28 Feet	28 Feet
Lime and Shale	167 "	195 "
Niagara	250 "	445 "
Shale	30 "	475 "
Clinton	27 "	502 "
Red Medina	42 "	544 "
Blue Shale	61 "	605 "
White Medina	9 "	614 "
Red Shale	50 "	664 "

Total Depth.............. 664 Feet.

Gas at 478, 569 and 610 feet.

Log No. 52; Information by C. W. Featherstone, Dunnville.

Lot.	Concession.	Township.	County.
"B"	Village of Indiana.	Seneca.	Haldimand.

Open flow: 55,000 cu. ft.
Rock pressure: 280 lbs.

Completed Mar. 22nd, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	43 Feet	43 Feet
Lime and Shale	182 "	225 "
Niagara	246 "	471 "
Shale	32 "	503 "
Clinton	26 "	529 "
Red Medina	39 "	568 "
Blue Shale	53 "	621 "
White Medina	10 "	631 "
Red Shale	50 "	681 "

Total Depth................ 681 Feet.

Gas at 507 and 522 feet.

Log No. 53; Information by C. W. Featherstone, Dunnville.

Lot.	Concession.	Township.	County.
24 and 25.	Village of Indiana.	Seneca.	Haldimand.

Open flow: 164,000 cu. ft.
Rock pressure: 260 lbs.

Completed April 13th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	50 Feet	50 Feet
Lime and Shale	172 “	222 “
Niagara	252 “	474 “
Shale	25 “	499 “
Clinton	26 “	525 “
Red Medina	42 “	567 “
Blue Shale	54 “	621 “
White Medina	10 “	631 “
Red Shale	50 “	681 “
Total Deph	681 Feet.	

Gas at 504, 525 and 572 feet.

Log 54; Information by F. L. Snively, Hamilton.

Lot.	Concession.	Township.	County.
10	3	Moulton.	Haldimand.

Open flow: 70,000 cu. ft
Rock pressure: 40 lbs.

Completed June 18th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	75 Feet	75 Feet
Shale Gypsum	146 “	221 “
Niagara Lime	223 “	444 “
Shale	52 “	496 “
Clinton	25 “	521 “
Red Medina	38 “	559 “
Blue Shale	63 “	622 “
White Medina	12 “	634 “
Red Shale	50 “	684 “
Total Depth	684 Feet.	

Log No. 55; Information by F. L. Snively, Hamilton.

Lot.	Concession.	Township.	County.
10	2	Moulton.	Haldimand.

Open flow: 84,000 cu. ft.
Rock pressure: 40 lbs.

Completed May 31st, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	80 Feet	80 Feet
Shale and Gypsum	139 “	219 “
Niagara Limestone	221 “	440 “
Grey Shale	55 “	495 “
Clinton	30 “	525 “
Red Medina	36 “	561 “
Blue Shale	61 “	622 “
White Medina	12 “	634 “
Red Shale	50 “	684 “
Total Depth	684 Feet.	

Log No. 56; Information by F. L. Snively, Hamilton.

Lot.	Concession.	Township.	County.
11	1	Seneca.	Haldimand.

Dry Hole.

Completed Nov. 4th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	62 Feet	62 Feet
Grey Lime	110 “	172 “
Niagara Brown	110 “	282 “
Grey Shale	40 “	322 “
Clinton Grey	35 “	357 “
Red Medina	40 “	397 “
Blue Shale	55 “	452 “
White Medina	10 “	462 “
Red Shale	45 “	507 “
Total Depth	507 Feet.	

Log No. 57; Information by T. J. McCutcheon, Dunnville.

Lot. 19	Concession.	Township.	County.
Culp Farm.	6	South Cayuga.	Haldimand.

Dry Hole.

Completed April 29th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	16 Feet	16 Feet
Flint	34 “	50 “
Grey Lime	60 “	110 “
Shale and Lime	250 “	360 “
Brown Lime	70 “	430 “
Niagara Lime	175 “	605 “
Black and Grey Lime	50 “	655 “
Grey Shale	55 “	710 “
Clinton	30 “	740 “
Red Medina	40 “	780 “
Grey Shale	55 “	835 “
White Medina	12 “	847 “
Red Shale	653 “	1,500 “
Red and Grey Shale	175 “	1,675 “
Grey Shale	600 “	2,275 “
White and Black Shale	175 “	2,450 “
Trenton Limestone	703 “	3,153 “
Total Depth	3,153 Feet.	

Log No. 58; Information by F. L. Snively, Hamilton.

Lot.	Concession.	Township.	County.
7	9	Walpole.	Haldimand.

Open flow: 21,000 cu. ft.
Rock pressure: 355 lbs.

Completed March 5th, 1921

Formation.	Thickness of Formation.	Total Depth.
Surface	15 Feet	15 Feet
Flint	60 “	75 “
Grey Lime	70 “	145 “
Shale	75 “	220 “
Guelph Lime	108 “	328 “
Shale and Lime	147 “	475 “
Niagara	216 “	691 “
Shale	98 “	789 “
Clinton Sand No. 1	34 “	823 “
Red Medina Sand No. 2	37 “	860 “
Blue Shale	35 “	895 “
White Medina	22 “	917 “
Total Depth	917 Feet.	

Log No. 59; Information by F. L. Snively, Hamilton.

Lot.	Concession.	Township.	County.
7	8	Walpole.	Haldimand.

Dry hole. Completed April 16th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	17 Feet	17 Feet
Flint	45 "	62 "
White Lime	9 "	71 "
Grey Lime	78 "	149 "
Shale	66 "	215 "
Guelph Lime	115 "	330 "
Shale and Limestone	134 "	464 "
Niagara Limestone	234 "	698 "
Clinton Shale	102 "	800 "
Red Medina	36 "	836 "
Blue Shale	44 "	880 "
White Medina	15 "	895 "

Total Depth .... 895 Feet.

Log No. 60; Information by J. J. McLister, Dunnville.

Lot.	Concession.	Township.	County.
1	1	North Cayuga.	Haldimand.

Open flow: 42,700 cu. ft.
Rock pressure: 175 lbs.

Completed March 15th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	45 Feet	45 Feet
Shale	135 "	180 "
Niagara	200 "	380 "
White Lime	43 "	423 "
Casing Shale	37 "	460 "
Clinton	25 "	485 "
Red Medina	40 "	525 "
Blue Shale	60 "	585 "
White Medina	15 "	600 "
Red Shale	25 "	625 "

Total Depth .... 625 Feet.

Log No. 61; Information by F. L. Snively, Hamilton.

Lot.	Concession.	Township.	County.
A	2	Moulton.	Haldimand.

Open flow: 6,000 cu. ft. with small show of oil.
Rock pressure: 127 lbs.

Completed July 23rd, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	90 Feet	90 Feet
Shale and Gypsum	110 "	200 "
Niagara	225 "	425 "
Grey Shale	51 "	476 "
Clinton	28 "	504 "
Red Medina	35 "	539 "
Blue Shale	50 "	589 "
White Medina	12 "	601 "
Red Shale	50 "	651 "

Total Depth .... 651 Feet.

LOG NO. 62; INFORMATION BY F. L. SNIVELY, HAMILTON.

Lot.	Concession.	Township.	County.
65	River Range.	Oneida.	Haldimand.

Open flow: 171,000 cu. ft.
Rock pressure: 220 lbs.

Completed Jan. 6th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface Clay	25 Feet	25 Feet
Guelph Shale	194 “	219 “
Niagara	211 “	430 “
Casing Shale	17 “	447 “
Grey Shale	36 “	483 “
Clinton	22 “	505 “
Red Medina	46 “	551 “
Blue Shale	46 “	597 “
White Medina	23 “	620 “
Red Shale	50 “	670 “

Total Depth 670 Feet.
Gas at 487 and 515 Feet.

LOG NO. 63; INFORMATION BY J. J. MCLISTER, DUNNVILLE.

Lot.	Concession.	Township.	County.
17	2	Canboro.	Haldimand.

Open flow: 17,000 cu. ft.
Rock pressure: 130 lbs.

Completed Dec. 5th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	46 Feet	46 Feet
Shale	120 “	166 “
Niagara	200 “	366 “
White Lime	50 “	416 “
Shale	24 “	440 “
Clinton	30 “	470 “
Red Medina	32 “	502 “
Blue Shale	60 “	562 “
White Medina	14 “	576 “
Red Shale	46 “	622 “

Total Length 622 Feet.
Gas at 490 and 578 feet.

LOG NO. 64; INFORMATION BY J. J. MCLISTER, DUNNVILLE.

Lot.	Concession.	Township.	County.
17	2	Canboro.	Haldimand.

Open flow: 43,000 cu. ft.
Rock pressure: 136 lbs.

Completed Nov. 11th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	33 Feet	33 Feet
Shale	117 “	150 “
Niagara	200 “	350 “
White Lime	50 “	400 “
Shale	36 “	436 “
Clinton	28 “	464 “
Red Medina	32 “	496 “
Blue Shale	60 “	556 “
White Medina	14 “	570 “
Red Shale	51 “	621 “

Total Depth 621 Feet.
Gas at 485 and 572

Log No. 65; Information by T. J. McCutcheon, Dunnville.

Lot.	Concession.	Township.	County.
5	S.F.R.	Moulton.	Haldimand.

Open flow: 20,000 cu. ft. Completed Oct. 27th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	105 Feet	105 Feet
Lime and Shale	160 "	265 "
Niagara	225 "	490 "
Shale	50 "	540 "
Clinton Rock	30 "	570 "
Red Medina	45 "	615 "
Shale	55 "	670 "
White Medina	12 "	682 "
Red Shale	25 "	707 "

Total Depth................ 707 Feet.

Gas at 545 and 677 feet.

Log No. 66; Information by T. J. McCutcheon, Dunnville.

Lot.	Concession.	Township.	County.
6	South Forks Road.	Moulton.	Haldimand.

Open flow: 40,000 cu.ft. Completed Aug. 21st, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	76 Feet	76 Feet
Lime and shale	184 "	260 "
Niagara	220 "	480 "
Shale	50 "	530 "
Clinton Rock	30 "	560 "
Red Medina	45 "	605 "
Shale	55 "	660 "
White Medina	12 "	672 "
Red Shale	50 "	722 "

Total Depth................ 722 Feet.

Gas at 535 feet.

Log No. 67; Information by T. J. McCutcheon, Dunnville.

Lot.	Concession.	Township.	County.
6	South Forks Road.	Moulton.	Haldimand.

Open flow: 20,000 cu. ft.

Completed Sept. 30th, 1921.

Formation.	Thickness of Formation.	Total Length.
Surface	82 Feet	82 Feet
Lime and Shale	180 "	262 "
Niagara	218 "	480 "
Shale	50 "	530 "
Clinton Rock	30 "	560 "
Red Medina	45 "	605 "
Shale	55 "	660 "
White Medina	12 "	672 "
Red Shale	51 "	723 "

Total Depth................ 723 Feet.

Gas at 535 feet.

Log No. 68; Information by Hoover & May, Selkirk.

Lot.	Concession.	Township.	County.
4	2	Seneca.	Haldimand.

Open flow: 29,000 cu. ft.
Rock pressure: 215 lbs.

Completed Dec. 24th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	38 Feet	38 Feet
Shale	93 “	131 “
Niagara	197 “	328 “
White Lime	31 “	359 “
Shale	34 “	393 “
Clinton	32 “	425 “
Red Medina	37 “	462 “
Grey Shale	54 “	516 “
White Medina	27 “	543 “
Red Shale	57 “	600 “
Total Depth	600 Feet.	

Log No. 69; Information by Hoover & May, Selkirk.

Lot.	Concession.	Township.	County.
3	2	Seneca.	Haldimand.

Open flow: 29,000 cu. ft.
Rock Pressure: 219 lbs.

Completed Jan. 14th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	48 Feet	48 Feet
Shale	88 “	136 “
Niagara	192 “	328 “
White Lime	17 “	345 “
Shale	34 “	379 “
Clinton	32 “	411 “
Red Medina	39 “	450 “
Grey Shale	54 “	504 “
White Medina	29 “	533 “
Red Shale	62 “	595 “
Total Depth	595 Feet.	

Log No. 70; Information by J. A. Coleman, Wellandport

Lot.	Concession.	Township.	County.
15	2	Moulton.	Haldimand.

Completed Nov. 28th, 1919.

Formation.	Thickness of Formation.	Total Depth
Surface	26 Feet	26 Feet
Lime Stone	141 “	167 “
Niagara	160 “	327 “
White Sand	20 “	347 “
Slate	50 “	397 “
Clinton	34 “	431 “
Red Medina	35 “	466 “
Slate	55 “	521 “
White Medina	10 “	532 “
Red Shale	68 “	600 “
Total Depth	600 Feet.	

LOG NO 71; INFORMATION BY F. L. SNIVELY, HAMILTON.

Lot.	Concession.	Township.	County
21	7	Binbrook	Wentworth.

Open flow: 40,000 cu. ft.
Rock pressure: 125 lbs.

Completed Oct. 1st, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	42 Feet	42 Feet
Brown Lime	83 "	125 "
Niagara	120 "	245 "
Grey Casing Shale	40 "	285 "
Clinton	35 "	320 "
Red Medina	43 "	363 "
Blue Shale	55 "	418 "
White Medin	10 "	433 "
Red Shale	50 "	483 "
Total Depth	483 Feet.	

LOG NO. 72; INFORMATION BY F. L. SNIVELY, HAMILTON.

Lot.	Concession.	Township.	County.
4	3	Binbook.	Wentworth.

Dry hole.

Completed July 5th, 1921

Formation.	Thickness of Formation.	Total Depth.
Clay	17 Feet	71 Feet
Brown Lime	76 "	147 "
Niagara	115 "	262 "
Grey Shale	40 "	302 "
Clinton	30 "	332 "
Red Medina	35 "	367 "
Blue Shale	55 "	422 "
White Medina	10 "	432 "
Red Shale	9 "	441 "
Total Depth	441 Feet.	

LOG NO. 73; INFORMATION BY WM. MCKILLOP, HEPWORTH.

Lot.	Concession.	Township.	County.
10	I	Flamboro West	Wentworth.

Open Flow: 6,000 cu. ft.

Completed April 6th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	231 Feet	231 Feet
Red Shale	200 "	431 "
Hudson	639 "	1,070 "
Black Shale	205 "	1,275 "
Trenton	793 "	2,068 "
Potsdam	55 "	2,123 "
Total Depth	2,123 Feet	

Gas at 296, 1,280 and 1,970 Feet.

Log No. 74; Information by F. L. Snively, Hamilton.

Lot.	Concession.	Township.	County.
1	4	Binbrook.	Wentworth.

Dry hole. Completed Feb. 19th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	64 Feet	64 Feet
Brown Lime	76 "	140 "
Niagara	115 "	255 "
Casing Shale	40 "	295 "
Clinton	30 "	325 "
Red Medina	35 "	360 "
Blue Shale	55 "	415 "
White Medina	10 "	425 "

Total Depth................ 425 Feet.

Log No. 75; Information by F. L. Snively, Hamilton.

Lot.	Concession.	Township.	County.
4	4	Binbrook.	Wentworth.

Open flow: 50,000 cu. ft.
Rock pressure: 150 lbs.

Completed June 15th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	76 Feet	76 Feet
Brown Lime	76 "	152 "
Niagara	115 "	267 "
Casing Shale	40 "	307 "
Clinton	30 "	337 "
Red Medina	35 "	372 "
Blue Shale	55 "	427 "
White Medina	10 "	437 "
Red Shale	50 "	487 "

Total Depth................ 487 Feet.
Gas at 337, 357 and 437 feet.

Log No. 76; Information by F. L. Snively, Hamilton.

Lot.	Concession.	Township.	County.
20	4	Binbrook.	Wentworth.

Open flow: 40,000 cu. ft.
Rock pressure: 125 lbs.

Completed Aug. 2nd, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay and Stone	80 Feet	80 Feet
Brown Lime	72 "	152 "
Niagara	110 "	262 "
Grey Shale	40 "	302 "
Clinton	30 "	332 "
Red Medina	32 "	364 "
Blue Shale	54 "	418 "
White Medina	10 "	428 "
Red Shale	50 "	478 "

Total Depth................ 478 Feet.
Gas at 332, 364 and 428 feet.

LOG NO. 77; INFORMATION BY F. L. SNIVELY, HAMILTON.

Lot.	Concession.	Township.	County.
20 blk. 4.	4	Binbrook.	Wentworth.

Open flow: 40,000 cu. ft.
Rock pressure: 125 lbs.

Completed Aug. 24th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	60 Feet	60 Feet
Brown Lime	76 "	136 "
Niagara	115 "	251 "
Grey Casing Shale	35 "	286 "
Clinton	30 "	316 "
Red Medina	35 "	351 "
Blue Shale	55 "	406 "
White Medina	12 "	418 "
Red Shale	50 "	468 "

Total Depth .... 468 Feet.
Gas at 316, 351 and 418 feet.

LOG NO. 78; INFORMATION BY F. L. SNIVELY, HAMILTON.

Lot.	Concession.	Township.	County.
19	7	Binbrook.	Wentworth.

Open flow: 40,000 cu. ft.
Rock pressure: 120 lbs.

Completed Sept. 12th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	48 Feet	48 Feet
Brown Lime	76 "	124 "
Niagara	115 "	239 "
Grey Casing Shale	40 "	279 "
Clinton	30 "	309 "
Red Medina	40 "	349 "
Blue Shale	55 "	404 "
White Medina	12 "	416 "
Red Shale	50 "	466 "

Total Depth .... 466 Feet.
Gas at 309, 349 and 416 feet.

LOG NO. 79; INFORMATION BY F. L. SNIVELY, HAMILTON.

Lot.	Concession.	Township.	County.
4	S. McKennall Farm.	Binbrook.	Wentworth.

Open flow: 40,000 cu. ft.
Rock pressure: 150 lbs.

Completed June 15th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	78 Feet	78 Feet
Brown Lime	76 "	154 "
Niagara	115 "	269 "
Grey Shale	40 "	309 "
Clinton	30 "	339 "
Red Medina	35 "	374 "
Blue Shale	55 "	429 "
White Medina	10 "	439 "
Red Shale	48 "	487 "

Total Depth .... 487 Feet.

LOG NO. 80; INFORMATION BY F. L. SNIVELY, HAMILTON.

Lot.	Concession.	Township.	County.
4	4	Binbrook.	Wentworth.

Dry hole. Completed Jan. 22nd, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	79 Feet	79 Feet
Brown Lime	76 "	155 "
Niagara Lime	115 "	270 "
Casing Shale	40 "	310 "
Clinton	30 "	340 "
Red Medina	35 "	375 "
Blue Shale	55 "	430 "
White Medina	10 "	440 "
Red Shale	3 "	443 "
Total Depth	443 Feet.	

LOG NO. 81; INFORMATION BY F. L. SNIVELY, HAMILTON.

Lot.	Concession.	Township.	County.
4	3 Near Halls Corners	Binbrook.	Wentworth.

Open flow: 40,000 cu. ft.
Rock pressure: 150 lbs. Completed May 24th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	78 Feet	78 Feet
Brown Lime	76 "	154 "
Niagara	115 "	269 "
Casing Shale	40 "	309 "
Clinton	30 "	339 "
Red Medina	35 "	374 "
Blue Shale	55 "	429 "
White Medina	10 "	439 "
Red Shale	48 "	487 "
Total Depth	487 Feet.	

LOG NO. 82; INFORMATION BY F. L. SNIVELY, HAMILTON.

Lot.	Concession.	Township.	County.
S½-1 & 2	4 Near Halls Corners	Binbrook.	Wentworth.

Dry hole Completed Feb. 19th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	64 Feet	64 Feet
Brown Lime	76 "	140 "
Niagara	115 "	255 "
Casing Shale	40 "	295 "
Clinton	30 "	325 "
Red Medina	35 "	360 "
Blue Shale	55 "	415 "
White Medina	10 "	425 "
Total Depth	425 Feet.	

LOG NO. 83; INFORMATION BY WM. MCKILLOP, HEPWORTH.

Lot.	Concession.	Township.	County.
28	1	Beverly.	Wentworth.

Completed Sept. 1921.

Formation.	Thickness of Formation.	Total Depth.
Clay	18 Feet	18 Feet
Quick Sand	192 "	210 "
Red Clay	14 "	224 "
Sand	161 "	385 "
Coarse Water Sand	55 "	440 "
Quick Sand	90 "	530 "
Sand and Gravel	7 "	537 "
Total Depth	537 Feet.	

LOG NO. 84; INFORMATION BY KISER & LOUER, TILLSONBURG.

Lot.	Concession.	Township.	County.
78	13	N. Walsingham.	Norfolk.

Open flow: 43,000 cu. ft.
Rock pressure: 605 lbs..

Formation.	Thickness of Formation.	Total Depth.
Surface	208 Feet	208 Feet
Lime	155 "	363 "
Flint	50 "	413 "
Sharp Sand	80 "	493 "
Hard Lime	54 "	547 "
Lime and Shale	84 "	631 "
Brown Lime	102 "	733 "
Hard Lime	151 "	884 "
Niagara Lime	257 "	1,141 "
Shale	67 "	1,208 "
Clinton	27 "	1,235 "
Red Medina	5 "	1,240 "
Grey Shale	24 "	1,264 "
Total Depth	1,264 Feet.	

LOG NO. 85; INFORMATION BY WESLEY HAMAKER, PORT DOVER.

Lot.	Concession.	Township.	County.
2	B. F.	Woodhouse.	Norfolk.

Open flow: 178,000 cu. ft.
Rock pressure: 555 lbs.

Formation.	Thickness of Formation.	Total Depth.
Surface	116 Feet	116 Feet
Flint	159 "	275 "
Sand	47 "	322 "
Lime	51 "	373 "
Lime and Shale	293 "	666 "
Niagara Lime	299 "	965 "
Shale	44 "	1,009 "
Clinton	23 "	1,032 "
Red Medina	20 "	1,052 "
Grey Shale	76 "	1,128 "
White Medina	28 "	1,156 "
Red Shale	1 "	1,157 "
Total Depth	1,157 Feet.	

Log No. 86; Information by Kiser & Louer, Tillsonburg.

Lot.	Concession.	Township.	County.
10	“B”	Walsingham.	Norfolk.

Open flow: 18,000 cu. ft.
Rock pressure: 475 lbs.

Formation.	Thickness of Formation.	Total Depth.
Surface	313 Feet	313 Feet
Lime	137 “	450 “
Flint	150 “	600 “
Niagara Lime	200 “	800 “
Shale	69 “	869 “
Clinton	20 “	889 “
Red Medina	27 “	916 “
Shale	5 “	921 “
Total Depth	921 Feet.	

Log No. 87; Information by George Williams, Delhi.

Lot.	Concession.	Township.	County.
31	3	Middleton.	Norfolk.

Open flow: 75,000 cu. ft.
Rock pressure: 550 lbs.

Formation.	Thickness of Formation.	Total Depth.
Surface	206 Feet	206 Feet
Lime	140 “	346 “
Flint	52 “	398 “
Sharp Sand	80 “	478 “
Hard Lime	52 “	530 “
Lime and Shale	83 “	613 “
Brown Lime	102 “	715 “
Hard Lime	150 “	865 “
Niagara Lime	257 “	1,122 “
Shale	41 “	1,163 “
Clinton	30 “	1,193 “
Red Medina	5 “	1,198 “
Grey Shale	34 “	1,232 “
Total Depth	1,232 Feet.	

Log No. 88; Information by Wesley Hamaker, Port Dover.

Lot.	Concession.	Township.	County.
1	Broken Front.	Woodhouse.	Norfolk.

Rock pressure: 485 lbs. Completed Nov. 7th, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	136 Feet	136 Feet
Lime	100 “	236 “
Flint	80 “	316 “
Sand	32 “	348 “
Lime	110 “	458 “
Lime and Shale	80 “	538 “
Lime	110 “	648 “
Shale	60 “	708 “
Niagara	272 “	980 “
Shale	60 “	1,040 “
Clinton	25 “	1,065 “
Red Medina	25 “	1,090 “
Shale	70 “	1,160 “
White Medina	17 “	1,177 “
Red Shale	2 “	1,179 “
Total Depth	1,179 Feet.	

LOG NO. 89; INFORMATION BY H. CABLE.

Lot.	Concession.	Township.	County.
Lever Farm. 135	3 U.S.R.	Artemesia.	Grey.

Drilled in 1917.

Formation.	Thickness of Formation.	Total Depth.
Surface	28 Feet	28 Feet
Niagara Lime	202 "	230 "
Blue Shale	40 "	270 "
Brown or Grey Rock	30 "	300 "
Blue Shale	5 "	305 "
Red Medina	265 "	370 "
Hudson River	400 "	770 "
Utica (brown)	170 "	940 "
Trenton Lime	40 "	980 "
Blue Shale and Gypsum	60 "	1,040 "
Trenton with Streaks of Shale	35 "	1,075 "
Shale and Slate	40 "	1,115 "
Gypsum and Conglomerate	25 "	1,140 "
Grey Rock	55 "	1,195 "
Trenton and Shale	100 "	1,295 "
Grey and blue rock	60 "	1,355 "
Trenton	185 "	1,540 "
Total Depth	1,540 Feet.	

Gas at 1645 and 1,695 feet. Oil at 1,715 feet.

Trenton lime conglomerate with shale gypsum and Potsdam sands to a depth of 1873 feet where Trenton lime ceases to show.

LOG NO. 90; INFORMATION BY W. H. MCDONALD, OSHAWA.

Lot.	Concession.	Township.	County.
24	7	St. Vincent.	Grey.

Completed July, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	10 Feet	10 Feet
Collingwood Shale	40 "	50 "
Hudson Shale	170 "	220 "
Utica Shale	60 "	280 "
Trenton	676 "	956 "
Arkose	20 "	976 "
Total Depth	976 Feet.	

LOG NO. 91; INFORMATION BY A. E. HOOVER, SELKIRK.

Lot.	Concession.	Township.	County.
16	1	Toronto.	Peel.

Completed Sept. 1920.

Formation.	Thickness of Formation.	Total Depth.
Surface	4 Feet	4 Feet
Hudson River	603 "	607 "
Utica	178 "	785 "
Trenton	605 "	1,390 "
Different Rocks	32 "	1,422 "
Granite	3 "	1,425 "
Total Depth	1,425 Feet.	

Log No. 92; Information by Jas. Pickering, Shelbourne.

Lot.	Concession.	Township.	County.
2	3	Melancthon.	Dufferin.

Drilled in 1907.

Formation.	Thickness of Formation.	Total Depth.
Surface	25 Feet	25 Feet
Niagara	115 “	140 “
Dolomite	20 “	160 “
Clinton	50 “	210 “
Blue Clay	100 “	310 “
Red Shale	320 “	630 “
Blue Shale	370 “	1,000 “
Soft Slate	225 “	1,225 “
Utica Shale	75 “	1,300 “
Trenton	650 “	1,950 “

Total Depth .... 1,950 Feet.

Log No. 93; Information by Kiser & Louer, Tillsonburg.

Lot.	Concession.	Township.	County.
33	1	Malahide.	Elgin.

Open flow: 70,000 cu. ft.

Completed, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	268 Feet	268 Feet
Lime	212 “	480 “
Flint	160 “	640 “
Lime	460 “	1,100 “
Niagara Lime	245 “	1,345 “
Shale	55 “	1,400 “
Clinton	22 “	1,422 “
Red Medina	30 “	1,452 “
White Shale	30 “	1,482 “
White Medina	35 “	1,517 “
Red Shale	5 “	1,522 “

Total Depth .... 1,522 Feet.

Log No. 94; Information by Kiser & Louer, Tillsonburg.

Lot.	Concession.	Township.	County.
34	1	Malahide.	Elgin.

Open flow: 201,000 cu. ft.
Rock pressure: 585 lbs.

Completed, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	280 Feet	280 Feet
Lime	220 “	500 “
Flint	150 “	650 “
Lime	425 “	1,075 “
Niagara Lime	285 “	1,360 “
Shale	54 “	1,414 “
Clinton	25 “	1,439 “
Red Medina	10 “	1,449 “
White Shale	36 “	1,485 “

Total Depth .... 1,485 Feet.

LOG NO. 95; INFORMATION BY KISER & LOUER, TILLSONBURG.

Lot.	Concession.	Township.	County.
35	2	Malahide.	Elgin.

Dry hole. Completed Oct. 21, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	277 Feet	277 Feet
Lime	203 "	480 "
Flint	150 "	630 "
Lime	445 "	1,075 "
Niagara	280 "	1,355 "
Shale	60 "	1,415 "
Clinton	16 "	1,431 "
Red Medina	13 "	1,444 "
Total Depth	1,444 Feet.	

LOG NO. 96; DRILLER GEO. KING, STRATHROY.

Lot.	Concession.	Township.	County.
7	5	Adelaide.	Middlesex.

Completed, 1921.

Formation.	Thickness of Formation.	Total Depth.
Surface	142 Feet	142 Feet
Top Rock	20 "	162 "
Soap	30 "	192 "
Black Lime	14 "	206 "
Grey Lime	52 "	258 "
Lime	100 "	358 "
Total Depth	358 Feet.	

Oil at 258 and 300 feet.

LOG NO. 97; INFORMATION BY DRILLER GEO. KING, STRATHROY.

Lot.	Concession.	Township.	County.
7	5	Adelaide.	Middlesex.

Completed June 15th, 1921

Formation.	Thickness of Formation.	Total Depth.
Surface	145 Feet.	145 Feet
Top Rock	20 "	165 "
Soap	30 "	195 "
Lime	76 "	271 "
Total Depth	271 Feet.	

Gas at 209, 230 and 245 feet.

LOG NO. 98; INFORMATION BY DRILLER GEO. KING, STRATHROY.

Lot.	Concession.	Township.	County.
7	5	Adelaide.	Middlesex.

Formation.	Thickness of Formation.	Total Depth.
Surface	155 Feet	155 Feet
Top Rock	20 "	175 "
Soap	30 "	205 "
Lime	72 "	277 "
Total Depth	277 Feet.	

LOG NO. 99; INFORMATION BY DRILLER F. L. SNIVELY, HAMILTON.

Lot.	1st Concession South	Township.	County.
4	Dundas Road	North Dorchester.	Middlesex.

Saul Farm. Completed Feb. 8th, 1921

Open flow: 237,000 cu. ft.
Rock pressure: 160 lbs.

Formation.	Thickness of Formation.	Total Depth.
Clay	125 Feet	125 Feet
Grey Limestone	54 "	179 "
Brown Lime	358 "	537 "
White Lime	39 "	576 "
Grey Lime and Hard Shale	149 "	725 "
Gypsum	56 "	781 "
Hard Shale	144 "	925 "
Guelph Lime	55 "	980 "
Hard Shale	25 "	1,005 "
Total Depth	1,005 Feet.	

LOG NO. 100; INFORMATION BY DRILLER F. L. SNIVELY, HAMILTON.

Lot.	1st Concession South.	Township.	County.
3	Dundas Road.	North Dorchester.	Middlesex.

Dry hole. Completed May 14th, 1921

Formation.	Thickness of Formation.	Total Depth.
Clay	139 Feet	139 Feet
Grey Limestone	54 "	193 "
Brown Lime	358 "	551 "
White Lime	39 "	590 "
Grey Lime and Hard Shale	149 "	739 "
Gypsum	56 "	795 "
Hard Shale	143 "	938 "
Salt Bed	35 "	973 "
Hard Shale	77 "	1,050 "
Total Depth	1,050 Feet.	

PETROLEUM IN 1921

The quantity of crude petroleum produced in Ontario in 1921 was 172,859 barrels of 35 Imperial gallons; 8,891 barrels less than in 1920. The principal cause of this decline is that the supply in two of the fields is giving out. There are other reasons also; the low price of oil, which fell from $4.09 per barrel in January to $1.98 in July, August and September, undoubtedly lessened the output. A glance at table 1, which gives the number of wells not operating, will show that, had the price been more stable, more properties would have been worked.

TABLE I.—CRUDE PETROLEUM PRODUCED IN 1921.

Field	Production		Wells			Average Production per operating Well	Gain or Loss in Production in 1921	
	bbls.	gals.	Operating	Non-Operating	Abandoned		Gain bbls.	Loss bbls.
Petrolia and						bbls.		
Enniskillen	68,483	32	1,681	859	125	40.74	3,402	......
Oil Springs	40,966	22	1,192	82	37	31.85	1,579	......
Moore Tp	7,536	04	94	15	26	80.27	500	......
Sarnia Tp	4,068	20	111	30	24	36.65	574	......
Plympton Tp	480	21	30	21	22	16.00	......	51
Bothwell	26,877	01	252	42	30	106.64	313	......
Tilbury East Tp	1,002	29	(a) 6				379	......
Dover West Tp	7,473	10	7			1,067.60	......	4,697
Raleigh Tp	3,320	13	20		4	166.00	2,832	......
Onondaga Tp	566	06	15	6		37.74	226	......
Mosa Tp	10,764	03	53	67		203.00	......	13,299
Thamesville	1,319	20	4			660.00	189	......
Belle River				24				
Dutton				76			......	837
Total	172,858	32	3,465	1,222	268		9,994	18,884
							Net Loss	8,890

(a) Production mainly from a large number of gas wells.

An examination of Table I, "gain and loss," shows, in spite of a general loss, a successful year's operations. With the exception of the Raleigh field, all the fields are old. The Petrolia field is entering its 60th year of continuous production, and after many years of gradual decline shows an increase of over 3,000 barrels, all without any new drilling. This is believed to be due, first to Inspector John Scott's diligence in searching out and plugging the abandoned wells that have been allowing surface water to flood the "oil sand." A glance at Table I, column "Wells not operating" will show that this is no simple matter. With so many idle wells, any of which might be leaking, it may mean that a score of them must be tested. Second: to the increased use of electric power for pumping oil wells; electric power is surer and steadier than gas engine power and increases production. The gas engine may stop in the evening, and wells idle for 10 hours may require days of pumping before oil will appear again. The other fields in Lambton county are practically as old as the Petrolia field, and are very similar.

The Raleigh field is mainly in the northwest corner of the township. The discovery of this field was noted in last year's report, and Dr. M. Y. Williams may fairly be given most of the credit for the discovery. It might still be enlarged. The limits are fairly well known, and it would appear that many more producing wells could be drilled, and the production greatly increased.

The increases shown in Tilbury East and Onondaga are more apparent than real, owing to an accumulation of crude petroleum shipped in January, which was really produced in 1920.

The sudden failure of the Mosa (Glencoe) field offsets the increase in the other fields. This heretofore excellent field only produced forty-five per cent. of its production in 1920. No reason can be given for this sudden failure excepting natural causes. However, a careful inspection of the sources of water might throw light on the decline. The West Dover field that has been a "flowing" one has been failing during the year on account of the depletion of the gas in the wells. The operating companies are installing pumps, and no doubt the year 1922 will show an improvement. The Thamesville field closed down in May owing to a disastrous fire that destroyed the pumping plant. The Dutton and Belle River fields were apparently inactive this year, although four wells are reported as operating at Belle River, and some of the wells in the Dutton field are reported as being "bailed." However, no oil was marketed from either field.

TABLE II.—CRUDE PETROLEUM PRODUCTION(1), BY FIELDS, 1917-1921.

Field	1917	1918	1919	1920	1921
	Bbls.	Bbls.	Bbls.	Bbls.	Bbls.
Petrolia and Enniskillen	74,267	65,467	70,087	65,082	68,483
Oil Springs	46,902	44,671	45,245	39,388	40,966
Moore township	6,282	6,367	4,029	7,036	7,536
Sarnia township	4,494	3,438	4,259	3,495	4,068
Plympton township	579	412	560	531	480
Bothwell	29,682	29,116	29,425	25,563	26,877
Dover, West } Tilbury	10,041	25,228	16,705	12,171	7,473
Tilbury, East } Tilbury			1,660	623	1,002
Raleigh township				(2)	3,320
Dutton	2,941	1,875	1,272	837	
Onondaga township	383	1,186	197	341	566
Belle River		447			
Mosa township	20,999	108,988	45,860	24,063	10,764
Thamesville	6,420	1,565	801	1,131	1,319
Total Production Bbls.	202,990	288,760	220,100	181,750	172,858
Value $	475,000	781,097	632,789	724,145	466,716
Average price per Bbl. (3) $	2.34	2.70½	2.87½	3.98½	2.68½

(1) Figures supplied to the Ontario Department of Mines by J. C. Waddell, Supervisor of Petroleum Bounties, Petrolia.

(2) Production for 1920 in Raleigh township was included with that of Dover West.

(3) A bounty of 52½ cents per barrel (35 Imperial gallons) or a total of $90,748.78 was paid in addition by the Federal Government under The "Petroleum Bounty Act."

Drilling Operations

Probably on account of the falling price of petroleum, there was little drilling activity during the year. Only two oil wells were drilled in Lambton county, both being in Moore township, and small producers.

In the Raleigh field the Eureka Oil and Gas Company drilled two wells, the Ajax Company four, the Pens Oil and Gas Company six, and the Inland Oil and Gas Company one dry hole.

John L. Hutton drilled a well on lot 27, con. 1, Mosa township, near Bothwell, a dry hole.

No other drilling activities are recorded in the old fields.

Exploratory Drilling

Several operators have turned their attention to Middlesex county, and much land has been leased over a very widespread area.

Actual drilling operations were begun by Messrs. Johnson and Hyett, Arkona, on a Trenton well not finished.

Bert Keyser started in 1920, and has drilled three shallow wells at Keyser's Corners.

The Central Ontario Petroleum Company has drilled two wells south of Kerwood: both had some oil, but the yield is not reported.

In the Kent county field, E. P. Rowe put down a shallow test well in lot 15, con. II Harwich, a dry hole.

The Valley Oil and Gas Company drilled a well to the granite one mile southwest of Dundas Station with a show of both oil and gas in the Trenton limestone.

Modern (standard) drilling rig.

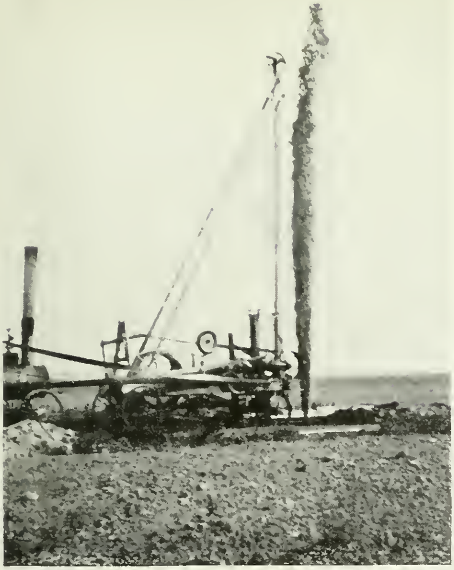
R. I. Henderson commenced a well two miles northeast of Bronte but has not completed it. Some gas was found in the Hudson River formation, but so far as known the Trenton was dry.

The Canadian Oil Fields, Limited, are drilling a well two miles east of Shelburne. No oil or gas is reported in the formations above the Potsdam sands, but this company claims to have a percentage of heavy oil in the rock 500 to 600 feet below the bottom of the Trenton limestone.

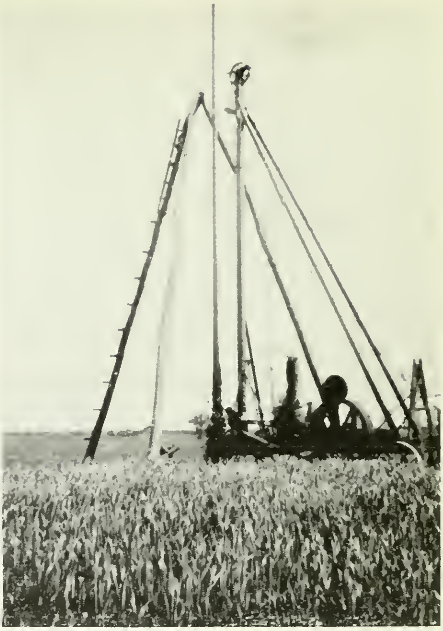
Some drilling was done in Manitoulin Island, but no reports have been received of the results.

Capt. C. M. McCarthy has a party organized to drill for oil with a diamond drill on the Mattagami river about 100 miles north of the Transcontinental railway. His party left on December 27th, and no reports will be received from him until the spring. He is using dog teams to take his supplies and equipment into this uninhabited country.

NSERT
LD-OUT
R MAP
HERE!



The right way



The wrong way

Shooting an Oil Well

When the casing is poorly seated or where the fluid level is above the bottom of the casing the escaping gases and debris are likely to lift the casing out. Of course misfortune may attend a well-placed shot, and even the debris escaping may lodge in the casing, and the compressed gasses force the casing out of the well. In the upper right hand picture the latter may have been the cause, as the fluid can be clearly seen shooting up between the drive-pipe and the string of casing that is being blown out of the well.

Map of Oil Fields

The map showing the oil fields of Ontario, past and present, is published to preserve the history of the oil development in Ontario as well as to serve as a reference for future development. Enquiries are often made as to where oil has been found in Ontario, and it is hoped that this will be of value to prospectors. It is not possible to show on a small scale all the test wells that have been drilled and have proved unproductive, but a very complete record of these wells is kept in the Natural Gas Commissioner's office and is available for reference by any one interested.

The original boundaries of the old oil fields are difficult to arrive at accurately, as the information must be got from the memory of the old operators, which is not always reliable. Neither do any of the old reports contain any accurate record of the limits of the old fields.

Acknowledgments are due for information received to Mr. Bookmiller of Tilbury, C. C. Roberts of Brantford, D. A. Coste of Niagara Falls, and many individual property owners on whose farms wells have been drilled.

Refining Operations

Four refineries operated in the Province in 1921, as noted hereunder:

PETROLEUM REFINERIES, 1921.

Company	Location of Refinery	Days Operated	Head Office Address
British American Oil Co., Ltd.	Toronto, Cherry St.	314	Toronto, Royal Bank Bldg.
Canadian Oil Companies, Limited	Petrolia	309	Toronto, Excelsior Life Bldg.
†Cities Service Oil Co., Ltd.	Wallaceburg	306	Wallaceburg.
Imperial Oil, Limited	Sarnia	312	Sarnia.

†This company took over the Great Lakes Oil Company's refinery on Mar. 1, 1921.

The following table, summarized from annual reports of the Ontario Department of Mines for the years 1907-1921 and Dominion Bureau of Statistics for 1921, shows refinery operations for the past five years:

TABLE III.—STATISTICS OF PETROLEUM REFINERIES, 1917-1921.

Schedule	1917	1918	1919	1920	1921
Crude petroleum production					
Imp. gals.	7,104,700	10,106,615	7,703,515	6,361,234	6,050,062
Value " $	475,000	781,097	632,789	724,145	466,716
American Crude, distilled,					
Imp. gals.	122,436,923	137,065,788	141,157,309	148,540,511	150,692,113
Value " $	9,236,033	12,612,882	12,486,174	20,102,784	14,537,339
Canadian Crude, distilled,					
Imp. gals.	8,122,062	9,513,222	7,693,385	6,402,118	5,880,086
Value " $	559,435	781,703	661,927	769,775	500,418
Per cent. of total	6.22	6.49	5.17	4.13	3.75
Products:					
Illuminating oil Imp. gals.	40,195,774	36,211,715	34,800,233	33,897,891	29,774,134
Value " $	3,457,817	4,239,816	5,073,647	6,331,706	3,335,200
Lubricating oil Imp. gals.	12,288,466	12,595,305	12,501,385	13,804,074	13,848,721
Value " $	1,586,270	2,118,002	2,293,640	3,276,569	2,351,975
Benzine, Naphtha, Gasoline Imp. gals.	34,611,056	39,156,447	44,625,590	47,418,420	51,033,337
Value " $	8,292,828	10,244,328	11,677,077	14,485,935	12,655,244
*Gas and Fuel oil, Tar, Imp. gals.	39,815,106	40,949,358	40,581,499	45,025,050	44,364,794
Value " $	2,671,414	2,943,503	2,265,457	5,486,636	2,130,685
Paraffin Wax and Candles lbs.	12,649,553	13,650,128	10,903,202	10,398,127	10,777,994
Value " $	908,996	1,148,726	1,044,798	973,805	310,267
Employees Ave. No.	1,289	1,312	1,580	1,736	1,560
Wages paid $	1,259,344	1,486,677	2,045,072	2,695,507	2,176,700

*Figures for 1921 do not include Tar product which was 18,971,400 pounds with selling value of $142,285.00.

INDEX
Vol. XXXI, Part V.

PAGE

- Abray, Thomas 26
- Acetylene.
  - Compared with natural gas 32
- Adelaide tp., boring records 70
- Ajax Oil and Gas Co. 46, 73
- Aldboro tp.
  - Gas consumption: population 18
  - Wells drilled 27
- Aldrich Gas and Oil Co. 23
- Amabel tp., wells drilled 27
- Ancaster tp. 19
- Artemesia tp., borings 68
- Artificial gas.
  - Compared with natural gas 32
- Aylmer.
  - Gas consumption; population 17
    - for industries 20
- Azoff Natural Gas Co. 25

- Bailing machine.
  - Description and photo 34-36
- Barton tp. 19
- Battle Natural Gas Co. 23
- Bayham tp.
  - Gas consumption: population 18
  - Wells drilled 27
- Beaver Oil and Gas Co. 23, 24, 26
- Beer, George 25
- Belle River.
  - Gas consumption: population 17
    - for industries 20
  - Oil field 72, 73
- Belmont.
  - Gas consumption 17
    - for industries 20
- Belmont Gas Light Co. 25
- Bermingham, T. C. 26
- Berry and Anderson 24
- Bertie tp.
  - Gas consumption; population 19
  - Wells drilled 27
- Beverly tp.
  - Boring records 66
  - Wells drilled 27
- Binbrook tp.
  - Gas consumption: production 19
  - Wells 27
    - records 62-65
- Binbrook Gas Co. 23, 25
- Blenheim.
  - Gas consumption: population 17
    - for industries 20
    - meter, orifice 4
- Bookmiller, Mr. 75
- Boring for gas.
  - Dufferin co. 69
  - Elgin co. 69, 70
  - Essex co. 48
  - Grey co. 68
  - Haldimand co. 50-61
  - Kent co. 38-47

PAGE

- Boring for gas—*continued.*
  - Middlesex co. 70, 71
  - Norfolk co. 66, 67
  - Operators licensed, list 24
  - Peel co. 69
  - Welland co. 49
  - Wells sunk, township list 27
  - Wentworth co. 62-66
- Boring for oil 73-75
- Bothwell oil field 73
- Brant co.
  - Gas consumption: population 18
    - wells sunk in 1921 27
- Brantford.
  - Gas consumption 17
    - peak, graph 14
    - for industries 20
    - rate of flow, diagrams 11
  - Population 17
- Brantford Gas Co. 25
- Bridgeburg.
  - Gas consumption: population 17
    - for industries 20
- British American Oil Co. 76
- Bronte. 74
- Brown, Geo. D. 46, 47
- Bruce co., gas wells 27
- Bunn, Forest 26
- Burners.
  - Method of altering, for economical cooking 4
- Burn, B. D. 3

- Cable, H. 68
- Caistor tp.
  - Gas consumption: population 19
    - wells 27
- Caledonia.
  - Gas consumption: population 17
    - for industries 20
- Camden tp. 18
- Canadian Oil Companies, Ltd. 76
- Canboro Gas and Oil Co. 23
- Canborough tp.
  - Boring for gas 27
    - records 59
  - Gas consumption: population 19
- Canby, B. F. 23
- Canfield Natural Gas Co. 23
- Castle Oil and Gas Co. 23-26
- Cayuga.
  - Gas consumption: population 17
- Cayuga tps.
  - Boring records 57, 58
  - Gas consumption: population 19
    - wells 27
- Central Ontario Petroleum Co. 74
- Central Pipe Line Co.
  - Appeal to adjust prices 3
  - Licenses to 24, 25
- Chamberlain, H. A. 24

PAGE
Charlotteville tp.
  Gas consumption: population 18
    wells 27
Chatham.
  Gas consumption: population 17
    for industries 20
    pressure 2, 3, *Facing* 13
Chatham tp. 18
Chatham Gas Co. 25
Chippawa 17
Chippawa Development Co. 23, 25
Chippawa Oil and Gas Co. 23, 25
Cities Service Oil Co. 76
Clover Gas and Oil Co. 24, 26
Coatsworth 20
Coleman, J. A. 24, 61
Comber 20
Competition.
  Inadvisable in gas industry 34
Consumers of gas, statistics 17-19
Contracts, percentage. *See* Percentage contracts.
Cooking by gas.
  Notes on economical methods 5-7
Copetown 28
Coste, D. A. 75
Courtright.
  Gas consumption: population 17
    for industries 20
Crowland tps.
  Gas consumption: population 19
    wells 27
      records 49

Danville 17
Darling Road Co-operative Co. 23
Dawn tp.
  Gas, new field 28
    wells 27
      record 49
Delhi.
  Gas consumption: population 17
    for industries 20
Dominion Natural Gas Co.
  Boring at Lakeview 28
  Licenses to 23-26
Dorchester tps.
  Gas consumption: population 18
    wells, records 71
Dover tps.
  Gas, consumption: 18
    meter, orifice 4
    wells 27
      records 44, 45
  Oil production 72, 73
  Population 18
Dresden.
  Gas consumption: population 17
    for industries 20
    meter, orifice 4
Drilling operations. *See* Boring for gas and oil.
Drilling rig, photo 74
Dumfries tp. 18
Dundas.
  Gas, consumption: population 17
    for industries 20

PAGE
Dundas—*continued.*
    meter, orifice 4
    new well 28
    price 22
  Oil, new well 28, 74
Dunn tp.
  Gas, consumption: population 19
    wells 27
Dunn Natural Gas Co. 25
Dunnville 20
Dunwich tp. 18
"Dust" trap, notes and photo 15
Dutton.
  Gas consumption: population 17
    for industries 20
    price 22
  Oil field, production 72, 73

Economy in using gas.
  Notes by Ohio State University 5-7
Electricity.
  Compared with natural gas 30
Elgin co.
  Gas consumption 18
    wells 27
      records 69, 70
  Population 18
Emerson, Laidlaw and Troughton 23
Empire Limestone Co. 23
Enniskillen oil field, production 72, 73
Enniskillen tp.
  Gas consumption: population 18
    wells 27
Essex.
  Gas consumption: poulation 17
    for industries 20
Essex co.
  Gas consumption: 18
    wells 27
      records 48
  Population 18
Estlin, E. S. 5
Euphemia tp.
  Gas consumption: population 18
    wells 27
Eureka Oil and Gas Co. 73

Factories.
  Gas for, statistics 20, 21
Featherstone, C. W. 24
Fisherville Gas Co. 25
Flamboro tps.
  Gas consumption 19
    wells 27
      records 62
  Population 19
Fonthill.
  Gas consumption: population 17
    supply 2
Ford 17
Fort Erie.
  Gas consumption: population 17
    for industries 20
Free consumers of gas 18, 19
Frontier Oil and Gas Co. 26

Gainsboro tp.
  Gas consumption: population 19
    wells 27

PAGE
Galt.
  Gas consumption: population ... 17
    for industries ... 20
Gas and Oil Co., of Springvale ... 25
Gas burners. *See* Burners.
Gas engines.
    Gas for, statistics ... 20, 21
Gas stoves. *See* Stoves.
Gasoline.
  Compared with natural gas ... 32
Glanford tp.
  Gas consumption: population ... 19
    wells ... 27
Glencoe oil field. *See* Mosa tp.
Glenwood Natural Gas Co. ... 23-26, 48
Gosfield tps.
  Boring records ... 48
  Gas consumption: population ... 18
    wells ... 27
Grantham tp.
  Gas consumption: population ... 19
Grey co., boring records ... 68
Grimsby tp.
  Gas consumption: population ... 19

Hagersville ... 17
Hamilton.
  Gas consumption: population ... 17
    for industries ... 20
    peak load ... 13
    pressure ... 9
Haldimand co.
  Gas consumption: population ... 19
    wells ... 27
      records ... 50-61
Hamaker, Wesley ... 66, 67
Hamilton Gas and Oil Co. ... 23
Harwich tp.
  Gas consumption: population ... 18
  Oil, boring for ... 74
Hendee Gas Co. ... 23
Henderson, Geo. F. ... 3
Henderson, R. L. ... 74
Hepworth ... 17
Highgate.
  Gas consumption: population ... 17
    for industries ... 20
High Grade Natural Gas Co. ... 25
Hoover, A. E. ... 68
Hoover and May ... 24, 61
Houghton tp.
  Gas consumption: population ... 18
    wells ... 27
Howard tp.
  Gas consumption: population ... 18
Humber, A. ... 39, 40
Humberstone ... 17
Humberstone tp.
  Gas consumption: population ... 19
    wells ... 27
Hussey, W. J. ... 45
Hutton, John L. ... 73
Hyett and Johnson ... 74

Imperial Oil Co.
  Acknowledgments ... 48
  License ... 24
  Oil refining ... 76

PAGE
Industrial gas consumers, statistics
    17, 18, 20, 21
Industrial Natural Gas Co. ... 23-26
Ingersoll.
  Gas, consumption: population ... 17
    for industries ... 20
Ingersoll Gas Light Co. ... 25
Inland Oil and Gas Co. ... 26, 73
Iron sulphate.
  Removal of, from gas ... 15
Irvine, J. J. ... 26

Jarvis.
  Gas consumption: population ... 17
    for industries ... 20
Jasperson, Bon ... 23, 24, 26, 28, 48
Johnson and Hyett ... 74

Kenney, John ... 49
Kent co.
  See also Kent gas field.
  Gas consumption ... 18
    price ... 22
    wells ... 27
      records ... 38-47
  Oil, boring for ... 74
  Population ... 18
Kent gas field.
  Report by Wyer ... 29-34
      ref to ... 2
  Volume; pressure: consumption 7,8
Kerlin, R. G. ... 2, 25
Kerosene.
  Compared with natural gas ... 32
Kerwood ... 74
Keyser, Bert L. ... 26, 74
Keyser Corners ... 74
King, Geo. ... 70
Kingsville.
  Gas consumption: population ... 17
    for industries ... 20
    meter, orifice ... 4
Kiser and Louer ... 24, 66, 69, 70

Lake Erie.
  Gas wells ... 36, 37
Lake Shore Natural Gas Co. ... 25
Lakeview ... 28
Lalor and Vokes ... 23
Lamb, A. ... 23
Lambton co.
  Gas consumption: ... 18
    wells ... 27
  Oil ... 72, 73
  Population ... 18
Leakage notes ... 14, 15
Leamington.
  Gas consumption ... 14, 17
    peak load, graph ... *facing* 14
    pressure ... 10
  License to town ... 25
  Population ... 17
Lever farm ... 68
Lincoln co.
  Gas, consumption: population ... 19
    wells ... 27

PAGE
Lindsay, Ernest 36
Logs of wells. *See* Boring for gas.

McCarthy, C. M. 74
McCutcheon, T. L. 24
McCutcheon, T. J. M. 57, 60
McDonald, W. H. 68
McKecknie, Sam 24
McKillop, Wm. 24, 62, 66
McLister, J. J. 24, 58, 59
Maidstone tp.
  Gas, consumption: population 18
Malahide tp.
  Gas, consumption 18
    wells 27
      records 69, 70
  Population 18
Manitoulin island 74
Manufacturers Gas Co. 25
Map, oil field. *facing* 75
Maple Leaf Oil and Gas Co. 26
Marshall, James 23
Mattagami river 74
Medina Natural Gas Co. 23
Melancthon tp. 69
Merritton 17
Mersea tps.
  Gas, consumption 18
    wells 27
      records 48
  Population 18
Meters.
  Orifice, notes and photo 4, 5
Middleton tp.
  Gas, consumption: population 18
    wells 27
      records 67
Middlesex co.
  Gas, consumption: 18
    wells 27
      records 70, 71
  Oil, boring for 74
  Population 18
Midland Natural Gas Co. 23, 25
Milkins, H. R. Jr. 26
Mills, Hon. Henry 29
Minor, L. E. 26
Moore tp.
  Gas, consumption: population 18
  Oil; boring for; production 72, 73
Mosa tp.
  Oil; boring for; production 72, 73
Moulton tp.
  Gas, consumption 19
    wells 27
      records 56-61
  Population 19
Muirkirk 20

National Gas Co. 23
Natural gas. *See also* Boring for gas.
  Measurement of 4
  Production
  Shortage 1, 2
  Substitutes for 32
  Supply, notes 7
Natural Gas Commissioner 2, 3

PAGE
Natural Gas Conservation Act 27
Niagara Falls.
  Gas consumption: population 17
    for factories 20
Nissouri tps. 27
Norfolk co.
  Gas, consumption 18
    wells 19, 21, 27
      records 66, 67
Northern Gas and Gasoline Co. 23, 25
Northern Pipe Line Co. 25
North Shore Gas Co. 23

Ohio State University.
  Notes by, on economy in using gas 5-7
Oil.
  Gas an incident of prospecting for 30
  Report 72-76
Oil Springs.
  Gas consumption: population 17
    for industries 20
  Oil production 72, 73
Oil Springs Oil and Gas Co. 23, 25
Oneida tp.
  Gas, consumption 19
    wells 27
      records
  Population 19
Onondaga tp.
  Gas, consumption; population 18
    wells 27
  Oil production 72, 73
Ontario Gypsum Co. 23
Open (Natural) flow.
  Notes by Wyer 29
Operators in natural gas.
  List of, licensed 23-25
Orford tp.
  Gas, consumption; population 18
Orifice meters.
  Notes and photo 4, 5
Oxford co.
  Gas, consumption: population 18
Oxford tp.
  Gas, consumption: population 18

Paris.
  Gas consumption: population 17
    for industries 20
Peak loads.
  Cities and towns 13, 14
  Effects, notes and diagrams 8-13
Peel co., boring records 69
Pelham.
  Gas, consumption: population 19
Pelham tp. gas supply 2
Pens Oil and Gas Co. 73
Percentage contracts.
  Abolition advisable 3, 29, 32
  Explanation of term 31
Petrol Oil and Gas Co. 23, 26
Petrolia.
  Gas for industries 20
Petrolia oil field 72, 73
Petrolia Utilities Co. 25
Pickering, James 69
Pilkington Bros. 23, 26

PAGE
Plympton tp. 72, 73
Point Abino 28
Population.
  Counties and townships 18, 19
  Towns and cities 17
Port Alma.
  Gas well opposite, notes and photo 36, 37
Port Colborne.
  Gas, consumption: population 17
    for industries 20
Port Colborne-Welland Natural Gas Co. 23, 25
Port Dover.
  Gas, consumption: population 17
    for industries 20
Port Rowan 17
Prairie Siding 20
Pressure of gas.
  Lowering recommended 33
  Various cities, diagrams 9-12
Putnam 21
Price of natural gas.
  Average retail 16
  Localities in gas district 17-19
  Notes by Wyer 34
  Ratio of, to gas consumed 22
Price of oil 72
Provincial Gas and Oil Co. 26
Provincial Natural Gas and Fuel Co.
  Appeal to adjust prices 3
  Boring at Point Abino 28
  Licenses to 23-26

Quillinan, J. A. 26

Rainham tp.
  Gas, consumption: population 19
    wells 27
Raleigh tp.
  Gas, consumption 18
    wells 27
      records 39-41, 45, 46
  Oil 72, 73
  Population 18
Randall, A. E. 39, 47
Rate of gas flow.
  Various cities, diagrams 9-12
Referee.
  Appointment of, and powers 27, 28
Refining operations, oil 76
Relief Gas Co. 2
Richmond Gas Co. 23
Ridgetown.
  Gas consumption: population 17
    for industries 21
Ridgeway 21
Roberts, C. C. 75
Robnett, C. W. 26
Rochester tp.
  Gas consumption: population 18
Rock pressure.
  Kent field, graphs 8, 31
  Notes by Wyer 29
Rodney.
  Gas consumption: population 17
    for industries 21

PAGE
Romney.
  Gas, consumption: population 17
  Wells drilled 27
Rosehill Natural Gas Co. 25
Rowe, E. P. 74
Rowe, S. P. 44

St. Catharines.
  Gas, consumption: population 17
    for industries 21
    peak load, graph *facing* 14
    rate of flow, diagrams 12
St. George 17
St. Vincent tp. 68
Sandwich 21
Sandwich tps.
  Gas consumption: population 18
Sarnia.
  Gas consumption 17
    for industries 21
    pressure to graph 13
    shortage 1-3
  Population 17
Sarnia tp.
  Gas consumption 18
    new field 28
    wells 27
  Oil production 72, 73
  Population 18
Sarnia Gas Co. 25
Saul farm 71
Scott, John 72
Sediment trap.
  For removing iron sulphate from gas, notes and photo 15
Selkirk 21
Seneca tp.
  Gas, consumption 19
    wells 27
      records 50-57
Shedden-Fingal 21
Shelburne 74
Sherbrooke tp.
  Gas consumption: population 19
    wells 27
Shetland Gas Co. 25
Simcoe.
  Gas consumption: population 17
    for industries 21
Smith, H. B. 26
Smith, R. H. 26
Snively, F. L. 24, 26, 56-65, 71
Sombra tp.
  Gas consumption: population 18
Southern Ontario Gas Co.
  Appeal to adjust prices 3
  Licenses to 24, 25
Southwold tp.
  Gas consumption: population 18
Sparham, A. F. 23
Staehling, E. H. 26
Stamford tp.
  Gas consumption: population 19
Sterling Natural Gas Co. 23, 25
Stevensville 21
Stevensville Gas Co. 23
Stover, F. H. 24

PAGE
Stover Drilling Co. 45
Stoves for "sulphur" gas 7
Stroup, John 38, 44, 46
Substitutes for natural gas 32
"Sulphur gas."
  Notes by Wyer 30
  Special stove for burning 7
Sundy Gas Well Co. 23
Symmes, H. D. 26

Tecumseh 17
Thames Oil and Gas Co. 26
Thamesville oil field 72, 73
Thorold.
  Gas, consumption: population .. 17
    for industries 21
Thorold tp.
  Gas consumption: population ... 19
Tilbury.
  Gas consumption: population ... 17
    for industries 21
Tilbury tps.
  Gas consumption 18
    meters, orifice 4
    wells 27
      records 38, 41-43, 46, 47
    See also Port Alma.
  Oil production 72, 73
  Population 18
Tillsonburg.
  Gas consumption: population .. 17
    for industries 21
Toronto 8
Toronto tp., boring record 68
Tupperville 17

Union Exploration Co. 24, 26, 29
Union Natural Gas Co.
  Appeal to adjust prices 3
  Licenses to 23-25
  Wells sunk by 41-43
    in Dawn tp. 28
United Gas and Fuel Co. 25
United Gas Companies, Ltd. 23-25
Universal Gas and Oil Co. 24, 26

Vacuum Oil and Gas Co. 23
Valley Oil and Gas Co.
  Boring at Dundas and Copetown 28, 74
  Licenses to 26
Vienna 17

Waddell, J. C. 73
Wainfleet tp.
  Gas consumption: population ... 19
    wells 27
Walkerville.
  Gas consumption: population .. 17
    for industries 21
Wallaceburg.
  Gas consumption: population .. 17
    for industries 21
Wallaceburg Gas Co. 4, 25

PAGE
Wallacetown 21
Walpole tp.
  Gas consumption 19
    wells 27
      records 50, 57, 58
  Population 9
Walsingham tp.
  Gas consumption: population .. 18
    wells 27
      records 66, 87
Waste of gas
  Notes by Wyer 30, 31
  Rules to prevent 33
Welland.
  Gas consumption: population .. 17
    industries 21
Welland co.
  Gas consumption 19
    wells 27
      records 49
  Population 19
Wellandport 21
Wells.
  List of, 1921 27
  See also Boring for gas.
Wentworth co.
  Gas consumption: population .. 19
    well records 62-66
Western Counties Gas Co. 26
West Lorne.
  Gas consumption: population .. 17
    for industries 21
Wheatley 17
Wiles, Charles H. 26
Williams, A. 26
Williams, M. Y. 72
Willoughby tp.
  Gas consumption: population .. 19
    wells 27
Windham tp.
  Gas consumption: population .. 18
    wells drilled 27
Windsor.
  Gas consumption: population ... 17
    for industries 21
    meter, orifice 4, 5
    pressure, graphs .... 9, *facing* 14
    shortage 1-3
Windsor Gas Co. 25
Winger, S. W. 26
Wolfe, E. 40, 41
Woodhouse tp.
  Gas consumption: population .. 18
    wells 27
      records 66, 67
Woodstock.
  Gas consumption: population .. 17
    for industries 21
Woodstock Gas Light Co. 25
Wyer, Samuel S.
  Report by, on Kent gas field ..2, 29-34

PROVINCE OF ONTARIO
DEPARTMENT OF MINES

HON. H. MILLS, MINISTER OF MINES — THOS. W. GIBSON, DEPUTY MINISTER

THIRTY-FIRST ANNUAL REPORT
OF THE

ONTARIO DEPARTMENT OF MINES

BEING
VOL. XXXI, PART VI,
1922

Geology and Minerals
OF THE
COUNTY of LEEDS

By
M. B. Baker

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY OF ONTARIO

TORONTO
Printed by CLARKSON W. JAMES, Printer to the King's Most Excellent Majesty
1923

Printed by
THE RYERSON PRESS

CONTENTS

Vol. XXXI, Part VI.

Page.

Introduction 1
Topography 2
Age classification of the rocks of the area 2
Grenville 3
  Crystalline Limestone 3
  Quartzite 4
  Gneisses 6
  Breccia 6
Laurentian 7
  Mica and Phosphate 9
Algoman 10
  Pegmatite dikes 11
  Feldspar 12
  Granite for Building Uses 13
Keweenawan 14
  Nickel and Iron Ore 15
Cambrian 16
  Iron Ores 16
  Building Stone 17
  Sandstone for glass-making . . . 18
Ordovician 20
Glaciation and its effects 20
Summary of Economic Minerals . . . 23

ILLUSTRATIONS

Page

Frontispiece . . . . *facing* 1
Fig. 1—Grenville crystalline limestone, showing original bedding preserved 4
Fig. 2—Grenville quartzite in perfect conformity with crystalline limestone 5
Fig. 3—Pseudo-conglomerate of fragments of paragneiss in matrix of crystalline limestone 7
Fig. 4—Grenville gneiss, showing prominent *lit-par-lit* intrusions of Laurentian . . 8
Fig. 5—Algoman pegmatite dike which cuts Algoman granite, Washburn 11
Fig. 6—Lyndhurst Granite Quarries, showing perfect jointing of the Algoman granite 13
Fig. 7—Joint blocks of Algoman granite from the quarries of A. C. Brown, Lyndhurst 14
Fig. 8—Grenville limestone and Algoman pegmatite, both cut by dike of Keweenawan trap 15
Fig. 9—Cliff-like front of Potsdam sandstone with conglomerate at base, resting on Grenville gneiss floor 16
Fig. 10—Contact of Black River limestone with Algoman granite 17

GEOLOGICALLY COLOURED MAP

No. 31c.—Leeds County, scale 2 miles to the inch. (*In pocket inside back cover.*)

Great War Veterans' Memorial at Lyndhurst, Leeds county. The Algoman granite from which the monument was cut came from the local quarry of A. C. Brown.

GEOLOGY AND MINERALS OF THE COUNTY OF LEEDS

By M. B. Baker

Introduction

Accompanying the report of the Royal Commission on the Mineral Resources of Ontario (1890) is a small scale map prepared from the various Dominion surveys made between the years 1842 and 1882. In the vicinity of the Thousand Islands this map shows the Paleozoic sediments lying against the pre-Cambrian complex, but the latter is shown merely under the old classification of Laurentian and Huronian.

In 1901 the Geological Survey of Canada issued a report[1] along with a map showing portions of the counties of Frontenac, Renfrew, Lanark, and Leeds. This map also outlines the Paleozoic and pre-Cambrian in much more detail, but no attempt is made to subdivide the pre-Cambrian, and it is therefore shown in one colour. The map shows that between Kingston on the west, and Brockville on the east, is a belt of pre-Cambrian rocks, which like an isthmus joins two very large areas of similar character, one to the northwest in eastern Ontario, and the other to the southeast in the State of New York, U.S.A.

In 1910 there was issued by the New York State Museum, Bulletin No. 145 "On the Geology of the Thousand Island Region," with a detailed description, and an excellent geological map of New York State. References were made to the probable continuation of some of these formations into Canadian territory. Thus it seemed advisable to have the area in Ontario immediately adjoining the boundary line, geologically surveyed, especially as the geology of this area is typical of a much larger one, which yields excellent economic deposits of mica, talc, phosphate, feldspar, quartz, and many other minerals. In 1916 the writer made a geological report with a map of the south part of Frontenac county for the Bureau of Mines.[2] The present report and map should be examined in conjunction with those of 1916, as the two are contiguous and together cover the geology of the area between Kingston and Brockville, about the Thousand Islands, and for a distance of approximately thirty miles north of the International boundary line.

The production of the map was supervised by W. R. Rogers, topographer of the Department of Mines, to whom the writer tenders his thanks.

Contoured roads maps issued by the Military Surveys Branch of the Department of Militia and Defence, Ottawa, were used as a base for the work in the south and east parts of the country. The Ontario Department of Highways supplied the base map for the balance of the area covered.

---

[1] Geol. Sur. Can., Vol. XII, Pt. 1. Iron Ore Deposits along the Kingston and Pembroke Railway, by E. D. Ingall.

[2] Ont. Bur. Mines, Vol. XXV, 1916, Pt. III. The Geology of Kingston and vicinity. By M. B. Baker.

Topography

The general topography of this area is that characteristic of pre-Cambrian formations occupying the eastern portion of Canada. The whole area represents a very ancient peneplain, the result of long periods of erosion, in which all prominences have been pretty well removed. The rocks making up the area are almost all metamorphosed, so that their schistose and gneissic structures have formed lines of weakness, along which erosion took place more readily than it did across the structure. The result has been a series of ridges and hollows whose longer axes lie northeast and southwest.

Differences in hardness of the rocks has given rise to a series of ridges and hollows, which correspond in direction with the general gneissic structure. The most pronounced hollows, usually occupied by lakes, are formed where the rocks were crystalline limestone, while the ridges forming the watersheds between the lakes and drainage channels are composed of the most resistant rocks, for example, granite gneisses or other metamorphosed igneous rocks.

Recent glaciation has refreshed this topography merely, but not produced it, for an examination of the area clearly shows that the present contour was developed before the Cambrian sediments were laid upon it. In many places thin outliers of Cambrian sediments still remain, and beneath these the old topography of pre-Cambrian rocks can be clearly seen. It differs in no way from the exposed portions, and shows plainly that the topography of the pre-Cambrian areas was developed in pre-Cambrian times. While locally it is very rough, being made up of mounds and hollows, swamps, lakes, and river valleys, there are no great contrasts in altitude. All the ridges are of about equal height, approximately 650 feet above the sea, so that the whole area presents an even sky-line, when viewed from the top of any one mound or ridge.

Age Classification of the Rocks of the Area

Below is the classification of the rocks, according to their age relations, used in this report and on the accompanying map. The oldest rocks are at the bottom of the table.

PLEISTOCENE	RECENT	Marl and peat beds, shallow water deposits, and sand dunes.	
	GLACIAL	Laminated clays, sand and fine gravel; all sorted products of glacial till. Boulder clay, unsorted glacial till.	
PALEOZOIC	ORDOVICIAN	Black River—	Leray and Lowville—coarse limestones. Pamelia formation—a fine-textured limestone. Rideau beds (basal member of Pamelia), shales, sandy limestones and conglomerates.
	CAMBRIAN	Potsdam—	Sandstones.

		GREAT UNCONFORMITY.
PRE-CAMBRIAN	KEWEENAWAN	Trap, diabase and gabbro intrusives.
		INTRUSIVE CONTACT.
	ALGOMAN	Coarse-grained granite and syenite intrusives, with later pegmatites.
		INTRUSIVE CONTACT
	LAURENTIAN	Grey to pink, medium to fine-grained, granitic gneisses.
		INTRUSIVE CONTACT
	GRENVILLE	White, coarsely crystalline limestone, with quartzite and rusty-weathering gneisses.
		Dark green to black gneisses, thoroughly impregnated with minute dikes of Laurentian granite, now also changed to gneiss.

Grenville

The earliest members of the geological record have been the subject of intensive study, re-grouping, and re-classification by many geologists. It is doubtful if any other group of rocks has received so much attention. The earliest geologists claimed that the pre-Cambrian was almost entirely a group of igneous rocks, in most complex relationship, and it was only in recent years that any appreciable amount of sedimentary material has been admitted to the pre-Algoman complex. It is now well established that a large part of the oldest formations yet discovered are sediments, and the Grenville is becoming a more comprehensive group than formerly.

In 1907 a paper[1] was written on "The Grenville-Hastings Unconformity" by W. G. Miller and C. W. Knight, in which they stated that a sedimentary series, which they called the Grenville, rested on an older floor of basic lavas, which they called the Keewatin. The Keewatin is therefore the oldest formation yet discovered in Ontario, and is entirely igneous in origin, and composed largely of basic lava flows. The Grenville, on the contrary, is almost entirely sedimentary in origin, a part being chemically deposited, and lies for the most part upon the Keewatin. Some of the beds are interlaid with the later Keewatin flows in much the same manner as are the Keweenawan sediments and volcanic flows of Keweenaw Point on Lake Superior.

In northwestern Ontario the Keewatin is abundantly present and the Grenville rather scarce. In southeastern Ontario, on the contrary, the Keewatin is practically wanting, while the Grenville is abundant. A glance at the map accompanying the report on the Kingston area[2] and the map accompanying this report brings this fact out very prominently. No recognizable Keewatin was seen in either area examined by the writer, but large areas of Grenville sediment are indicated.

Crystalline Limestone

The most easily recognized member of the Grenville series is crystalline limestone, but closely associated with this are quartzites, rusty-weathering gneisses, and dark green to black micaceous, hornblende, or garnetiferous gneisses and schists. The limestones are as a rule coarsely crystalline, the individual grains being frequently as large as peas. They are rather pure as a whole, but in many places contain flake graphite, phlogopite, hematite, chondrodite, vesuvianite, diopside, quartz, and other minerals. Their softer character has rendered them more susceptible to erosion than the accompanying rocks, so that they occupy the basins of the various lakes of the area, and are also the valley bottoms of many of the northeast-southwest drainage channels. This is a very pronounced feature of the area, and is well brought out on the accompanying map. The section which accompanies the map, and which cuts across the strikes of the rocks, shows well the depressed portions of Grenville limestone, due to its rapid erosion, as compared with the more resistant areas of Algoman granite, or Grenville and Laurentian gneisses.

---

[1] Ont. Bur. Mines, Vol. XVI, 1907, Pt. 1. Page 221.
[2] Idem, Vol. XXV, 1916, Pt. III.

The original bedding of the limestones can still be seen in many places, and shows the series to be standing at high angles from 40 to 65 degrees, Fig. 1.

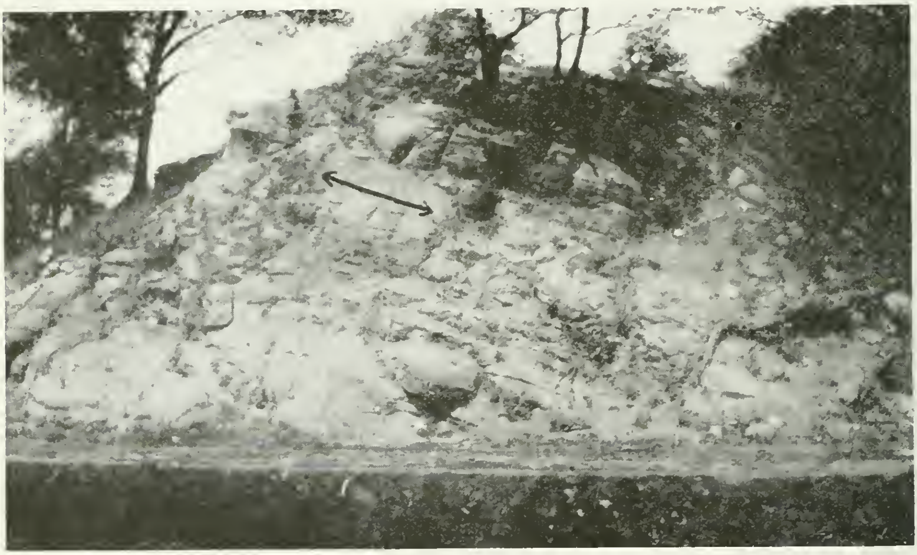


Fig. 1.—Grenville crystalline limestone, showing original bedding preserved.

The constancy of strike in this series, and the pronounced isoclinal dip of most cross-sections, have led to numerous discussions as to the total thickness of these sedimentary beds. The writer attempted to work out the structure from the crystalline belts, but found the dips so variable that he was unable to do this satisfactorily. It would appear, however, that the great belts of gneiss, crystalline limestone, and quartzite shown on the accompanying map are due to repeated isoclinal folding of the Grenville series, and do not indicate the enormous thickness of original sediments asserted by some investigators. Even this conception means that each of these belts would represent a series of great thickness, tilted up at a high angle.

Quartzite

The Grenville quartzite is a compact greenish to white rock, often showing the distinct banding or bedding of the original sandstone from which it was formed, Fig. 2. The masses are so dense and hard that they form very prominent features in the landscape, usually standing up as distinct ridges with their long axes running northeast and southwest, while softer members of the Grenville series occur in parallel hollows and valleys. In many places the quartzite is in contact with the crystalline limestone, and small bands of quartzite from two to ten inches thick are interlaminated with the limestone.

Analysis of this quartzite is given below:

	Per cent.
SiO_2	98.14
CaO	.35
Al_2O_3	.88
Fe_2O_3	.41
	99.78

This quartzite would be suitable for the manufacture of silica refractories, e.g. silica brick, but it is not suitable for glass manufacture on account of the crushing which it requires, and which would give a very high percentage of angular fines.

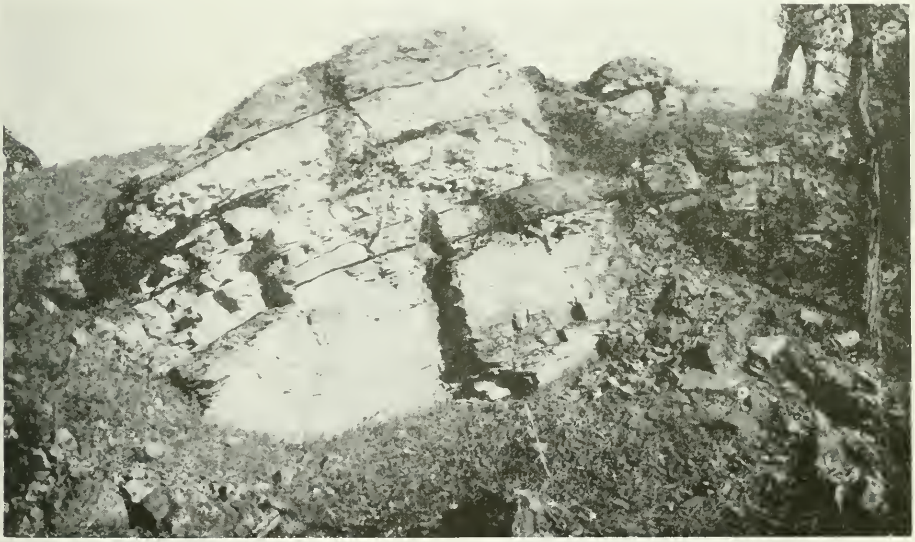


Fig. 2.—Grenville quartzite in perfect conformity with crystalline limestone, showing original bedding of both and the superior hardness of quartzite.

In examining any unmetamorphosed section of sedimentary rocks the outstanding features will admittedly be the prominent bedding planes; the continuity of composition and texture along the bedding; and the abrupt and numerous changes in composition and texture across their bedding. Keeping these features in mind, one would expect that a metamorphosed series of sedimentary rocks would show, in addition to the gneissic or schistose structure, a marked banding or belting in the direction of the original bedding, and a variety of colours and textures in the several bands, depending on their changing composition, across the former bedding. This is a feature of the Grenville series that cannot be too much emphasized.

Gneisses

Great belts or zones of rusty-weathering gneisses, together with green to black micaceous, hornblendic, or garnetiferous gneisses are to be found throughout the area under consideration. They are shown on the map in blue coloration, and their pronounced northeasterly extension is very evident. They are closely inter-belted with bands of crystalline limestone or with quartzite. The rusty-weathering effect is due to the oxidation of pyrites, which most of them contain in scattered grains. The most prominent feature of these gneisses is their pronounced platy cleavage in addition to the gneissic texture. Usually this platy cleavage corresponds in direction with the gneissic texture, and also with the dip and strike of the accompanying crystalline limestone belts.

Chemical analysis of highly metamorphosed rock is of value in determining the origin of the series, especially when taken in conjuction with field relationships. Samples of these gneisses were therefore selected and the analyses are shown below.[1]

SiO_2	Al_2O_3	Fe_2O_3	$Ca O$	$Mg O$	K_2O	Na_2O	$C O_2$	$X O$	Total
45.14	11.20	2.40	20.42	3.26	3.86	2.90	10.08	....	99.26
48.34	12.71	5.43	19.85	1.66	2.51	2.64	2.90	3.92	99.52
59.08	13.90	3.30	10.68	3.50	4.23	1.61	1.05	3.40	100.75

The writer has already stated his doubt as to the value of chemical analyses of highly metamorphosed rock, but considered in the light of field relationships, distribution, and geological form of occurrence, rock analyses certainly offer evidence of reliable and confirmatory value. The low percentage of silica and potash might suggest a basic igneous rock, but the accompanying low percentage of ferro-magnesian constituents preclude this possibility. The rather high percentage of alumina and calcium carbonate confirm the claim for a highly calcareous set of sediments, accompanying the crystalline limestones and quartzites. From the field relationships and the analyses it is probable that the rusty-weathering gneisses represent sandy sediments which were originally present with the limestone, and which suffered metamorphism along with it, in order to produce the gneissic characters now shown.

Breccia

A very frequent occurrence in the area is a pseudo-agglomerate or breccia. made up of fragments of gneiss in a matrix of crystalline limestone. In many cases the fragments of gneiss are in alignment, or carry out a warp or curve indicating a flow-like structure, Fig. 3. They undoubtedly represent the more resistant, brittle fragments of the paragneisses that have been mashed up with the crystalline limestone when undergoing deformation. The limestone being so much softer, simply mashed up and flowed about the brecciated gneiss. This is a very striking rock, and is abundant throughout the area. It forms one more proof that the belted gneisses, accompanying the crystalline limestone, are of sedimentary origin, and were clayey to sandy impure sediments of Grenville age, which suffered metamorphism along with the purer limestones and sandstones to form the highly complicated and intimately mixed group now known as the Grenville series.

---

[1] Analyses by W. K. McNeill, Provincial Assayer, Toronto.

In addition to the calcareous group just described and mapped in blue colour, there are many other areas of micaceous and hornblendic gneisses in parallel position with the calcareous belts, but they lack the lenses of crystalline limestone. Their outstanding feature is their platy cleavage, in addition to the gneissic texture. They also are believed by the writer to be largely impure sediments, but he is unable to prove that they are not partly igneous in origin. They may represent a most intimate mixture of Grenville sediments with inter-laminated Laurentian intrusions in *lit-par-lit* injection. For this reason they are mapped in a different colour, green. In many places they resemble the gneissic parts of the typical Grenville, but in other places they are so characteristically granitic or syenitic, that their resemblance to the Laurentian is more striking. As they may be a mixture of the Grenville with the Laurentian, they are so mapped by the writer.

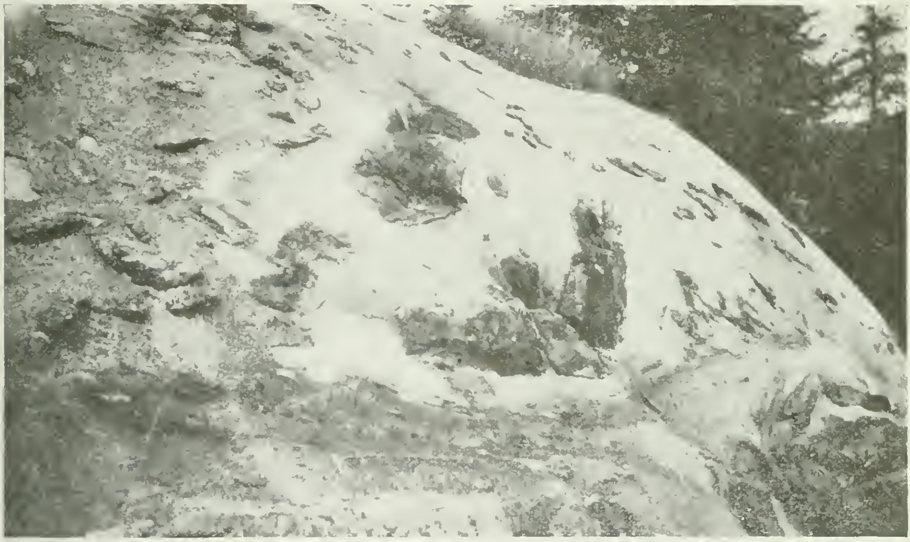


Fig. 3.—Pseudo-conglomerate of rusty-weathering fragments of paragneiss in a matrix of Grenville crystalline limestone.

Laurentian

The Laurentian has been defined by the International Committee on nomenclature as consisting of the great masses of gneissic granite that invade the Grenville series, and nothing younger.[1] It is essential that this point be insisted upon because another series of pink granites, often somewhat gneissic, invades the Grenville and also later formations, and it is only by stratigraphic field examination that these two can be definitely distinguished. The Laurentian is granitic for the most part, but also has syenitic phases. It is medium to fine-grained, pinkish to grey in colour, and always strongly gneissic in texture. A small amount of mica (biotite) is usually present, and this serves to bring out prominently the gneissic structure on weathered surfaces. There are three belts of predominantly Laurentian rocks, sufficiently large and free from accompanying Grenville material to show their real character, exposed in the area mapped. One of these extends from just east of Gananoque in a northeasterly direction along the river front to Yonge Mills. A second area is shown west of Newboro lake, while a third area, and much the most characteristic one, occupies all the northern part of the township of South Crosby. A chemical analysis by W. K. McNeill from the second of these areas mentioned shows it to be a typical granite converted into gneiss by metamorphism.

---

[1] Jour. Geol., Vol. XV, 1907, Page 216.

$Si\ O_2$	Al_2O_3	$Fe\ O$	Fe_2O_3	CaO	MgO	K_2O	Na_2O	$X\ O$	Total
64.45	14.11	0.10	8.96	tr	0.19	7.20	1.62	3.64	100.27

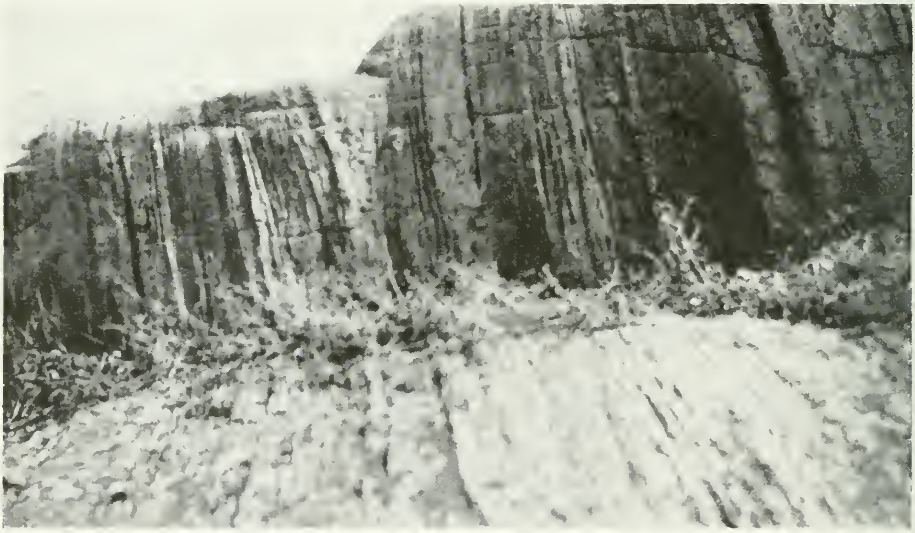


Fig. 4.—Grenville gneiss, showing prominent *lit-par-lit* intrusions of Laurentian.

In addition to the larger masses of Laurentian gneiss there are areas, as mentioned above under the discussion of the Grenville, which show a most intimate mixture of minute intrusive dikes of Laurentian rocks into the bedded Grenville sediment. They appear as abundant lens-like bands whose longer axes correspond to the gneissic and bedded direction of the sediments, Fig. 4.

A typical area of this kind extends from just north of Gananoque Junction northeasterly to Charleston lake. Another area is shown about Sand lake, just north of Jones Falls. Here excellent exposures of the crushed or mashed Grenville are seen where the intrusive Laurentian granite appears to have caused the crushing.

These minute dikes of Laurentian granite are so numerous that it is difficult to determine which formation predominates. It is therefore scarcely possible to decide whether the area should be mapped as Grenville or Laurentian. A mixed symbol has accordingly been used for them. In many places the alternate bands of Grenville and Laurentian gneisses are not over half an inch thick, and are repeated so often as to produce a most striking result. Many of the small Laurentian dikes jog across the bedding of the Grenville gneiss from layer to layer, so as to preclude the possibility of their being contemporaneous in age.

No close examination of the Grenville where it is intruded by large masses of Laurentian rock, can fail to emphasize the importance of the contact of these two. Almost everywhere that a large body of Laurentian intrudes a similar body of Grenville rocks, a zone of contact metamorphism is the result. Many contact minerals were generated, and some in such large quantities as to be of economic value. Two of these, apatite or calcium phosphate, and phlogopite or amber mica, have been largely mined; while a third mineral, calcite, or coarsely crystallized limestone, is now being mined and is finding a market in ground form in the manufacture of paints, and as a filler for paper.

Mica and Phosphate

Southeastern Ontario has long been known as an important producer of phlogopite or amber mica. In the "Geology of Canada," issued by the Geological Society in 1863, reference is made by Sir William Logan to the occurrence of mica in this area. He says, "it appears probable that by further exploration in this region and in Grenville, sufficient quantities of mica could be obtained to supply a large demand."

All early reports of mica occurrences speak of its association with phosphate, and in fact, the phosphate industry flourished long before the mining of mica was carried on. In 1868 apatite was mined by the Rideau Mining Company in North Burgess township, and was shipped to Germany. It then brought seven dollars per ton. In 1871 apatite was discovered in the township of Loughborough by H. G. Vennor. Mica then began to be mined as a by-product in the phosphate industry. It was not, however, until after 1890 that there was any appreciable demand for mica. Of the great quantity that had been mined in the phosphate industry, and thrown on the dumps, only a very small portion of the choicest sizes found a market.

After 1890 both mica and phosphate found sale for a time, but the placing of the easily mined phosphates of the southern states on the market, soon stopped the sale of the harder and more costly phosphate of southeastern Ontario. A demand for this phosphate is being revived, however, and the Chemical Products Limited of Trenton, Ontario, is now in the market to purchase a supply. It is not the writer's intention to deal in detail with the mica industry. Monograph No. 118 on mica, issued in 1912 by the Mines Branch, Department of Mines, Ottawa, is full of information for those who wish particulars. Suffice it to say that along the contact of the Laurentian intrusives with the highly calcareous Grenville formation were developed scattered crystals of pyroxene, phlogopite, apatite, calcite, scapolite, graphite, and other minerals, showing clearly that these minerals were brought into being as contact metamorphic crystallizations, and were the result of a siliceous magma coming in contact with a dolomitic country rock.

In many cases the contact produced a rather fine-grained crystalline rock composed largely of pyroxene, mica, and apatite, which may easily be taken for a pyroxenite, and from its position would appear to be intrusive, as has been so frequently claimed. At other places more open and spacious contacts developed larger crystals, and it is from these that the merchantable mica and apatite are got. Pyroxene crystals six inches square, apatite crystals up to ten inches in diameter, sphene four inches across, and zircons half an inch to a side and an inch and a half in length, and other crystals of similar dimensions have made these localities famous as collecting grounds for the mineralogist. The writer would therefore advise prospectors for mica, to search out contacts of Grenville sediments (mapped in blue colour) with Laurentian gneisses (mapped in green) and follow these contacts for the location of economic deposits. That the granitic intrusion which caused the metamorphism and mineralization, was Laurentian in age, and not Algoman, is certain, because both Algoman and later rocks cut these mica-phosphate deposits.

Algoman

In their work in southeastern Ontario, Miller and Knight showed that a series of intrusive granites and syenites cut the Hastings group, which they considered the equivalent of the Timiskaming series.[1] These intrusives are called Algoman. The writer cannot prove that the igneous masses which he has placed in the Algoman are post-Timiskaming, but they are clearly later than the Laurentian, for they cut it, and since they correspond in every other respect with the post-Timiskaming intrusives of the area lying immediately to the northwest, and described by Miller and Knight, he believes them to be identical in age, i.e.. Algoman.

Similar occurrences are found in the Thousand Islands region described by Cushing in his report of that area.[2] Regarding these rocks Cushing says:—

> This (Picton granite) is the latest, most extensive, most interesting, and most extensively quarried. . . . . . Across the border in Canada, it seems to have large extent, though it has not yet been differentiated from the Laurentian in mapping. If, however, we are correct in correlating the granite at Kingston, Ontario, with this rock, a batholith of considerable extent is implied. The general rock is rather a bright red granite of quite coarse grain. It varies much in this respect, however, and much of the border rock is of much finer grain. Red feldspars constitute 75 per cent. or more of the rock. Considerable quartz is usually present, and is frequently characterized by a slightly bluish cast, which makes a helpful diagnostic feature of the rock. Hornblende and biotite are sufficiently abundant to show prominent black spots in the otherwise red rock. In all likelihood the rock can be carried across on the Canadian islands to the mainland, and thence west to Kingston, but until this has been done some reserve must be felt in making the correlation.

A casual examination of these later granites, syenites, and their accompanying dikes, causes one to hesitate in attempting to distinguish them from typical Laurentian members which they so closely resemble. Where the Timiskaming series is present the age of these granites and syenites is of course readily determined. Even where no Timiskaming is present by which to fix the ages of the Algoman, a close examination brings out the following characteristics:—The rock is coarser-grained than the Laurentian, and is composed of pink orthoclase and microcline feldspars, with quartz bluish to milky coloured instead of clear, glassy, and colourless. Biotite and hornblende are often present, but occur in larger grains and are not so abundant as in the Laurentian members. The rocks are distinctly redder in general appearance, noticeably fresher and undecomposed. They are very much less gneissoid than the Laurentian; in fact, most of the granites and syenites of Algoman age show no gneissic structures at all, and are typical medium- to coarse-grained, plutonic crystallizations.

---

[1] Ont. Bur. Mines, Vol. XXII., 1913, Pt. II. P. 130.

[2] New York State Museum Bulletin 145.

A gneissic structure is, however, often shown fairly well developed along the margins of the mass, but even here such structure is indicated rather by the drawn-out character or alignment of the dark minerals, than by the crushed and dynamically squeezed appearance of typically Laurentian gneisses. This alignment of dark constituents in the Algoman borders appears to be due more to a flow structure produced while the mass was still potentially liquid, by a rubbing or flow along its margins, than to true gneissosity due to subsequent dynamic forces. From these main differences it is possible to distinguish with a great degree of certainty between Laurentian gneisses and the much later Algoman granites and syenites, even when these are gneissic in structure.

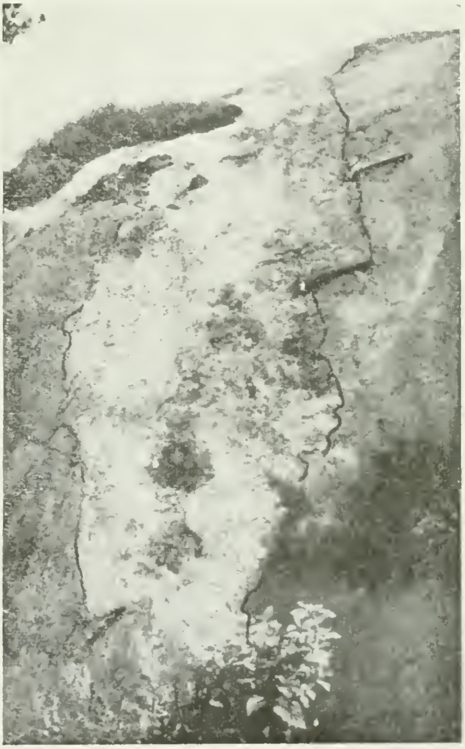


Fig. 5.—Algoman pegmatite dike which cuts Algoman granite, Washburn, Rideau canal.

Pegmatite Dikes

As a final phase of the Algoman intrusion, and after it had cooled sufficiently to be jointed and fractured, came a series of pegmatite dikes, which showed a considerable tendency to differentiate, Fig. 5; so much so, that large economic deposits of feldspar, and of quartz have resulted in many cases. This feldspar is pink in colour and is largely microcline; at other times it is an intimate mixture of orthoclase and microcline, in microperthitic texture. The quartz of the pegmatites is also in sufficiently large masses to be mined separately, and used in the manufacture of ferro-silicon bronze, and in other industries requiring silica.

Where these Algoman pegmatite dikes cut Grenville or Laurentian gneisses, they form coarse-textured, pink-coloured dikes whose feldspar is rich in potash, running usually 13 per cent. On the other hand, where these dikes cut Grenville crystalline limestone, they yield white or bleached-looking pegmatites, composed of pale, white feldspars carrying about 6 per cent. of potash and 3 per cent. of soda. In these white pegmatites, moreover, there is not the same tendency to differentiation as in the pink ones, and in no deposit seen by the writer was the feldspar sufficiently free from quartz intergrowth to yield merchantable feldspar. Contemporaneous crystallization yielding graphic granite texture, seems to have been the rule in these dikes. Even fragments of apparently clear white feldspar, when examined under a microscope, show abundant micro-pegmatitic intergrowths of quartz.

Dr. Cushing, in his report on the Thousand Islands region, records similar effects where granitic dikes cut crystalline limestone. He adds the very interesting information that he discoloured the pink feldspars by heating them over an ordinary Bunsen burner in the presence of limestone.[1]

Feldspar

Feldspar in more or less pure form has been mined from the Algoman pegmatite dikes of eastern Ontario for twenty years. It is used chiefly in the glazing of electric insulators, reflectors, toilet and bath equipment, earthenware. china, decorative tile, etc. It is also used in finely ground form in the manufacture of the body of heavy insulators for hydro lines, all classes of common earthenware, and floor tile. For these purposes it is mixed with ground quartz and with a good quality of china clay. The moulded or dry-pressed article is fired to a solid porcelain-like body, and is later glazed or not as required.

It is to be noted that for glazing purposes the feldspar needs to be as pure as it is possible to get it, otherwise checks, blotches, flaws and discolorations appear. For the manufacture of earthenware or porcelain a certain percentage of quartz is not objectionable, for in any event quartz will be later added in the mix. The writer has mentioned above that two classes of Algoman pegmatite dikes occur. In one the ingredients are so well segregated or differentiated that clean feldspar can be obtained from them, such as is demanded by the glazing industry. In the other pegmatites it was pointed out that they took on a graphic granite texture where the quartz and feldspar are most intimately mixed. If the percentage of quartz is not too high, say over 15 per cent., these dikes can be used and cobbed to a saleable product for the porcelain. tile, or earthenware industry, but the material will not command so high a price. These two features should be clearly borne in mind in prospecting for feldspar, or in offering it for sale to the manufacturer. It should also be remembered that the presence of mica. hornblende, or tourmaline will condemn the product for either use, so that many otherwise promising feldspar deposits are useless on this account. These minerals cause flaws, uneven textures, and discolorations of the article, or of the glaze, as the case may be.

---

[1] New York State Bulletin No. 145, Page 179.

Granite for Building Uses

The Algoman masses of granite and syenite show jointing as a rule, and in many places the jointing is remarkably good, Figure 6, allowing the rock to be quarried into fine building blocks and monumental stones, while the smaller waste pieces are readily trimmed to paving blocks or cobble-stone. A promising industry is being built up in paving blocks, and also larger granite monumental or building-blocks in this vicinity. The Woodburn Granite Quarries, Gananoque, operated by Charles Gordon and associates, and the Lyndhurst Granite Quarries at Lyndhurst belonging to A. C. Brown, are the chief producers at present. These granites are being used also for polished and lettered monuments, and for red to pink granites the writer has no hesitation in recommending them as the equal of anything in colour and durability he has seen. A good example is seen in the Great War Veterans' memorial monument erected at Lyndhurst. (*See Frontispiece*). This stone was supplied from the quarries of A. C. Brown, situated near the western end of the large exposure of Algoman granite extending westward from the village of Lyndhurst to Whitefish lake, Figs. 6 and 7. Tombstone men will do well to look into this source of supply before going to the expense of importing red granites, that are in no way superior, but cost much more.

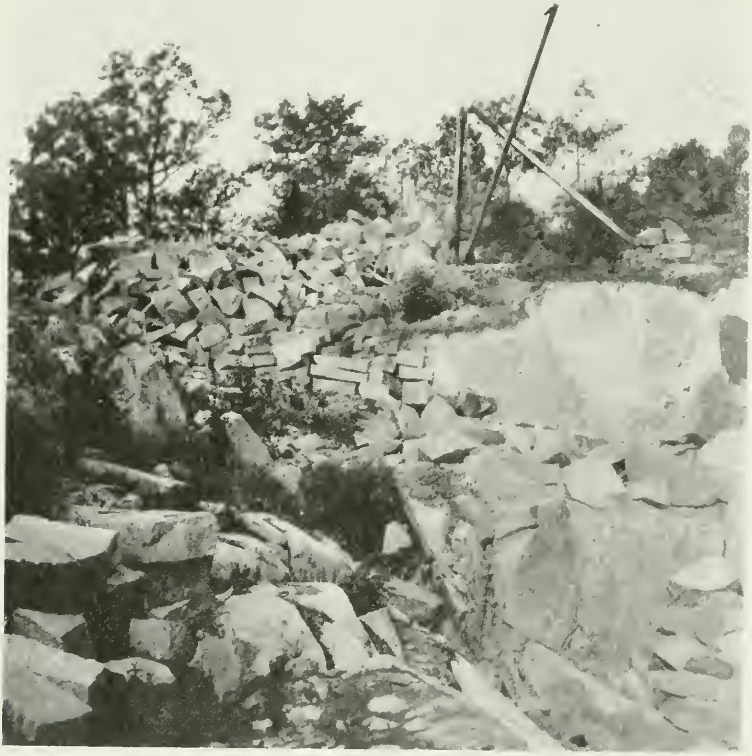


Fig. 6.—Quarries Lyndhurst Granite, showing perfect jointing of the Algoman granite.

Keweenawan

The youngest of the pre-Cambrian rocks in the county of Leeds is a group of diabases, traps and gabbro intrusives. These cut the Algoman as well as all earlier rocks. In other parts of Ontario a great series of sediments, which lie unconformably on the Algoman, and which are known as Animikie in age, are cut by a similar set of basic dikes and sills, and their age is therefore fixed. Since in this area no Animikie rocks are to be found, it can only be said that these later dikes are post-Algoman, but as was the case in considering the Algoman, the perfect similarity of material and structure seems to justify the correlation of these basic intrusives with the proven Keweenawan of other areas. The only alternative is to introduce other periods of igneous activity than those generally recognized throughout the pre-Cambrian rocks of Ontario, and this is much less justifiable than to correlate them with the already well-known and established periods.

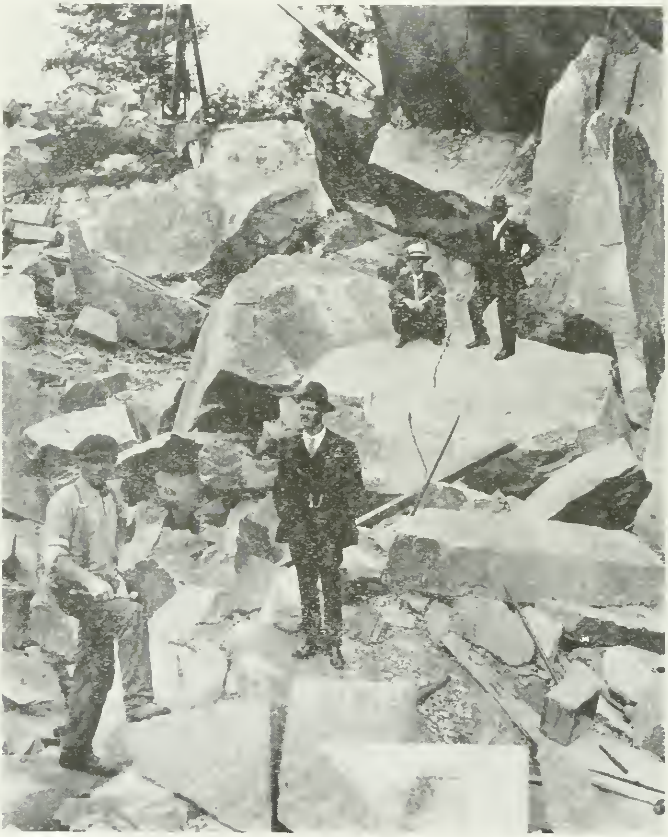


Fig. 7.—Joint blocks of Algoman granite from the quarries of A. C. Brown, Lyndhurst.

These dikes and intrusives vary from fine-grained traps to coarse gabbro-like masses. A microscopic examination of them shows that they are mostly augite diabases, whether fine or coarse-grained. They show the most beautiful ophitic textures, with lath-like blades and crystals of basic plagioclase, cutting into and through large honey-coloured crystals of augite. Their texture is therefore identically like that of the other well-known Keweenawan areas of northern Ontario. Moreover, they carry traces of nickel, a further strong evidence from the standpoint of consanguinity. They are remarkably fresh and undecomposed, and are therefore believed to be the youngest of the pre-Cambrian rocks in this area, Fig. 8.

Nickel and Iron Ore

Dr. Willet G. Miller drew attention to the possible economic value of these basic intrusives in 1897[1] where he notes the occurrence of nickel in the titaniferous magnetites associated with them. An investigation of these titaniferous magnetites showed the presence of nickel in every case, and often cobalt in traces as well. The now famous deposits of nickel, cobalt and silver of the Cobalt region of northern Ontario are of this same age.

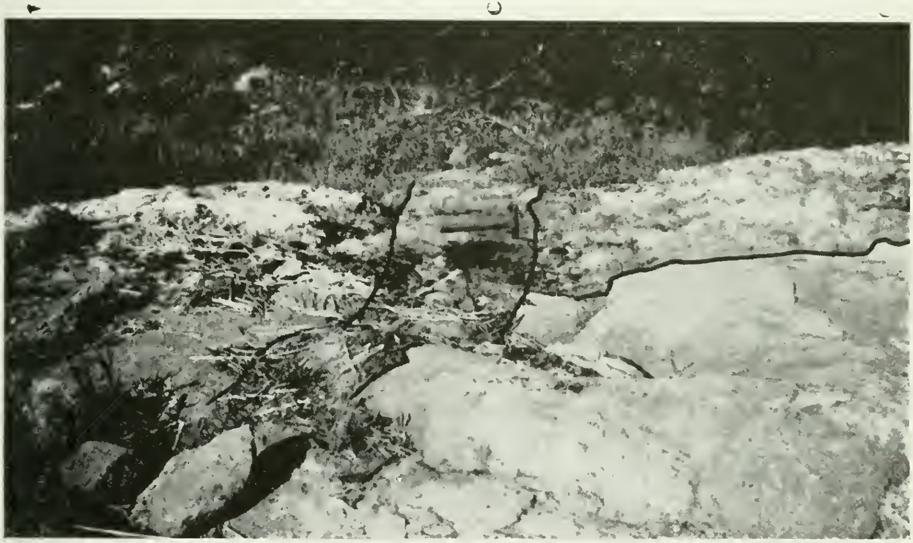


Fig 8.—Grenville crystalline limestone cut by Algoman pegmatite and both of these cut by a vertical dike of Keweenawan trap.

It has also been claimed that the iron produced from titaniferous ores is a tougher and better iron for many purposes than that from non-titanium ores. More recent improvements in electrical smelting strongly suggest a market in the near future, for these hitherto condemned ores.

Regarding segregations of iron ore in the coaser-grained gabbroic masses, only two are found in the area under consideration. They are known as the Chaffey mine, lot 26, con. VI, in the township of South Crosby; and the Matthews mine, lot 1, con. VI, in the township of North Crosby. Both of these deposits were worked as early as 1858, and continued operating in a desultory fashion till 1871. The ore was shipped by water to Cleveland, Ohio, and by rail from there to Pittsburg. Analyses of this ore show metallic iron varying between 50 and 60 per cent., while titanium oxide ran from traces to as much as 16.4 per cent.: no analysis for nickel content was given.

---

[1] Ont. Bur. Mines, Vol. VII, 1897, p. 230.

Cambrian

The intrusions of the Keweenawan period closed the pre-Cambrian in this as in other parts of Ontario. A long interval of weathering and erosion followed, during which the Keweenawan and all earlier rocks were subjected to processes of denudation to such an extent as to produce practically the same topography as we find to-day over the whole of the pre-Cambrian. This must have been a very long period of erosion, for the country was almost base-leveled. This feature has been well preserved by the earliest sediments of the Paleozoic seas; and small outliers of these sediments, which remain to-day, show the underlying pre-Cambrian floor to have exactly the same contour and general character as that of the exposed areas. Glaciation, of course, eroded both the pre-Cambrian and the later rocks, and has served merely to freshen the existing topography of the country, but did not produce it.

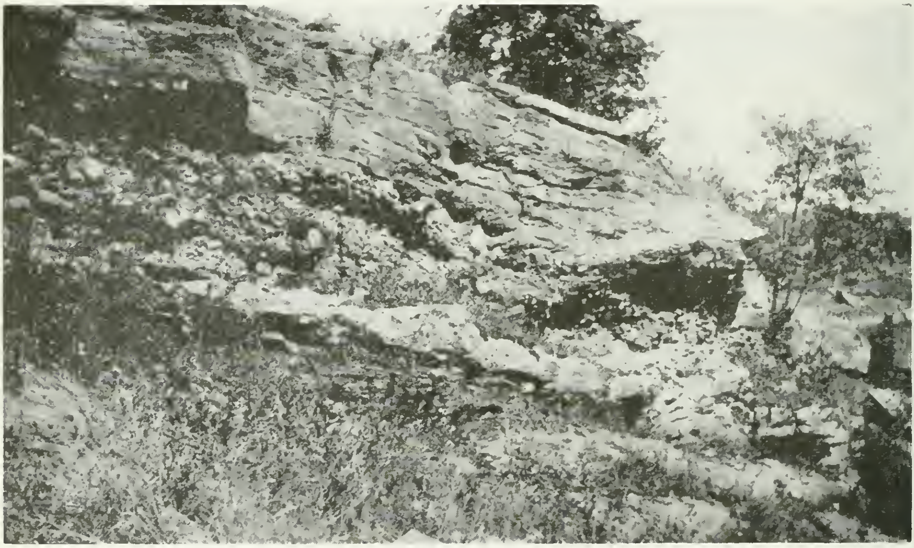


Fig. 9.—Cliff-like front of Potsdam sandstone with conglomerate at base, resting on Grenville gneiss floor.

Overlying this pre-Cambrian floor we find first the Potsdam series. In most places there is a basal conglomerate up to four feet thick, composed of well-rounded, water-worn pebbles and boulders of quartzite, Fig. 9. One striking feature of all these basal conglomerates is the absence of any of the softer rocks. Scarcely any pebbles or boulders of dark gneiss, schists, or crystalline limestone are to be seen, but only the harder quartzite, as stated above.

Iron Ores

In many cases these basal conglomerates are cemented by a brown to deep red iron oxide. This is so abundant in places that some of them have been opened up as prospects for hematite iron, for example, lot 13, Con. IX, and lot 23, Con. X, in the township of Bastard. On these lots a number of pits were opened up, but shipping ore was not found in any appreciable tonnage. Most of the hematite is ochreous, but much of it was solidified to a massive state.

They are merely masses of shattered sandstone and conglomerate richly impregnated by ochreous hematite. In some cases the iron oxides follow down the bed of the sandstone giving the appearance of a true vein, but there is no evidence of filling from below, merely the leaching down of the oxide from the overlying beds of sedimentary rock. In every case the ore is highly siliceous from original sand grains imprisoned with the iron oxide accumulation.

A very interesting deposit of hematite occurs on lot 4, Con. V. in the township of South Crosby. A pocket in the old Grenville crystalline limestone became filled with ochre that had leached down from the overlying Potsdam sandstone. This sandstone had subsequently been eroded so that the pocket of exposed red ochre was left. This was mined and shipped in sacks to a paint factory. The pocket was small, but the few tons of ochre secured were very clean, and of the best quality.

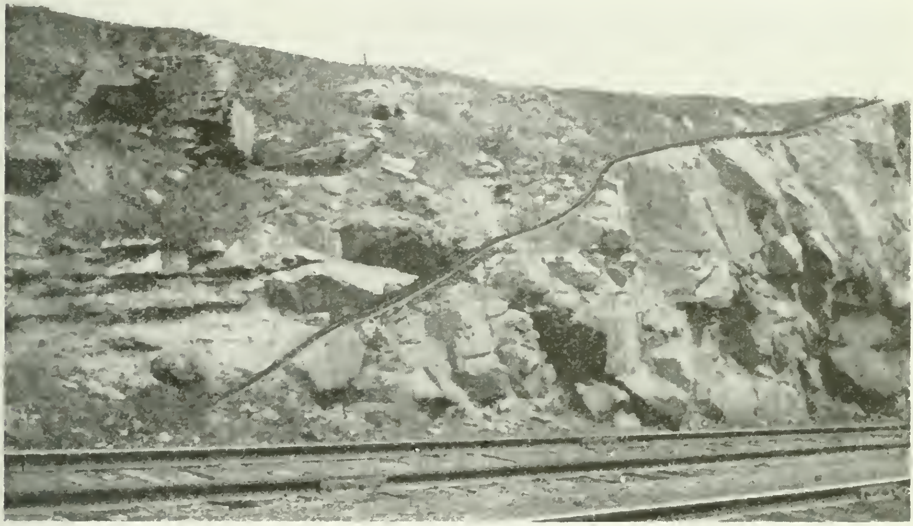


Fig. 10.—Contact of Black River limestone (above) with Algoman granite (below).

Building Stone

Above this basal conglomerate the Potsdam is, as a rule, a rather even-grained, uniform sandstone, with a total thickness of about sixty-five feet. There appear to be two members in the series, one a buff to red sandstone with ferruginous cement, in places upwards of twenty feet in thickness. The other is an equally thick group of sandstones, very pure and very white in colour, and apparently later in age than the red beds.

The buff to red sandstones are not always present beneath the white ones, because they conformed to the surface of the pre-Cambrian floor on which they were deposited. Moreover, they were evidently laid in shallow water, as indicated by the crossed bedding, and the abundance of ripple marks to be found on them. It was pointed out above that the pre-Cambrian area is one of low ridges with hummocky topography, and with broad-bottomed, relatively shallow basins and valleys. The extremes of local relief would seldom be over 150 feet, but even this was sufficient to cause many island-like areas of pre-Cambrian rocks to remain above the shallow Cambrian sea: thus the valleys and basins only would have the earliest sandstone laid down in them. The later white sandstone would in some places cover these, but in many other places would rest directly on the island-like pre-Cambrian areas just mentioned. Even the later Cambrian seas did not entirely submerge all the islands, for in many places the still later Ordovician limestones rest directly on the pre-Cambrian, with splendid basal conglomerates, Fig. 10. In most cases, however, these limestones rest conformably on the sandstones of Cambrian age.

The margins of the limestone as they rest on the sandstones, and of the sandstones as they rest on the pre-Cambrian rocks, are often cliff-like. This is no doubt to be accounted for by the bedding, as well as by the jointing of the sediments, causing them to weather and drop away in blocks, rather than wear down in a tapering contact.

The buff to reddish sandstone of Cambrian age is well adapted for building purposes, and has been quarried and used in many buildings in the county of Leeds. The stone is even-grained, free from fossils or other porous cavities, has good bedding, and a durable cement. The white sandstones are very much harder, and not so well suited to quarrying in building block sizes. They are now being used in large quantities throughout the county of Leeds for road building. Crushed white sandstone yields a good hard road metal, and is giving excellent results on the roads within reach of the deposits.

Paving Blocks

These lighter coloured siliceous sandstones are also suitable for paving blocks, and may be quarried and hammer-trimmed to cobblestone size. The natural bedding planes may be selected to yield layers three and one half inches thick, and from these it is an easy task to trim blocks 3½ x 4 x 8 inches in size. When these blocks are laid on their edges, so that the bedding planes stand vertically, they yield an excellent material for road paving, or for street-railway lining. These blocks are now in use in the city of Kingston. Princess street, the main business street of the city, and the one subjected to the heaviest traffic, has now been paved with these blocks for eight years, and not a stone has required replacement.

When it is remembered that this rock is made up almost entirely of quartz, one of the hardest of minerals, and is bound by a siliceous cement, its great resistance to wear is not surprising. The blocks are much less brittle than paving bricks, and do not readily wear to round edges.

Sandstone for Glass=Making

Believing that this pure white siliceous sandstone had possibilities in the glass and porcelain industries, also possibly for refractory linings of furnaces, the writer collected some of this sandstone, and has made it the subject of a special investigation. An advanced student of geology at Queen's University, J. W. Greig, was given the problem of making a physical and chemical investigation of this material, and the results of his work are summarized as follows:—

In order that a sandstone may be suitable as a source of silica for the manufacture of glass it must fulfil a number of conditions. The most important of these is a required chemical composition. No sand occurring in nature is pure silica, and each of the impurities affects the glass in a different way. The most prevalent impurity is alumina (Al_2O_3). This may be present in the sand in the form of feldspar, clay, or other aluminous silicate, in small pieces which have not been destroyed in the weathering down of the original rock, or as clay between the grains of quartz. The latter is the more likely. Alumina, although an impurity, is not detrimental, however, in the small quantities usually found in a glass sand, but it has the following effects on the glass: (1) It appears to reduce the tendency of a glass to devitrify or crystallize. (2) Three to four per cent. of alumina in a glass renders it less susceptible to the reducing effect of a flame. (3) It reduces the co-efficient of expansion of a glass. (4) It increases the tenacity and the surface tension of the molten glass, and this is very beneficial in moulding. (5) It increases the brilliancy, and decreases the solubility of a glass in water. From the above points and others it will be seen that alumina not above three per cent. is beneficial to a glass rather than injurious.

The most detrimental impurity likely to be found in a sand is iron. It imparts a cream colour to the stone, and washing will frequently remove a great part of it. Ferrous iron, even in small quantities, imparts a bluish to greenish colour to the glass. So common is this impurity that almost any glass, in thick sections, will be seen to have a greenish cast. This effect can often be overcome by what are called discolorizers, the most common of which is manganese dioxide. This material added to a glass imparts a violet shade, which neutralizes to some extent the green due to iron. But this neutralizing is accomplished chiefly by absorption of light rays, so that the transparency of the glass is impaired. Most authorities agree that iron should not exceed 0.05 per cent. in the sand, although the glass sands of Belgium, which are extensively used for sheet and plate glass, contain as much as 0.25 per cent. of iron.

Clay or alumina in glass is said to cause a cloudiness, and consequently any sand with a clay content which cannot be removed by washing should not be used in the manufacture of glass.

Silica is the useful part of the sand, and the percentage should be as high as possible. Whether or not a sand is suitable for glass manufacture can be best seen by a chemical analysis showing the percentages of impurities. Most glass sands contain upwards of 97 per cent. of silica. The sand grains composing the sandstone should be fairly uniform in size. On crushing, the material should break between, and among the grains, rather than across them. The size of the grains is of considerable importance. With large grains the length of time required to flux is longer, and therefore the output of the furnace is lessened. On the other hand, very fine-grained material is said to "burn out" in the batch. Thorough mixing of the ingredients is also very difficult when the grains are very fine, and there is likely to be considerable loss from the finest sand going up the flue with the draught. The most suitable sizes of grain appear to be between 80 and 20 mesh. The grains may be either angular or rounded, and there does not appear to be any consensus of opinion as to which is the more suitable form.

Below are given both chemical and mechanical analyses of two glass sands most used in the United States. There is also a sample of the white Potsdam sandstone collected by the writer. No. 1 is Keystone No. 1, produced by the Keystone works of the Pennsylvania Glass Sand Co., near Mapleton, Penn. This is an angular sand. No. 2 is a well-rounded sand produced by the Wedron White Sand Co. of Ottawa, Ill. No. 3 is the white Potsdam sandstone from lot 19, Con. 1, township of Pittsburg, county of Frontenac, Ontario.

CHEMICAL ANALYSES OF SANDS

No.	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO
1	99.36	0.17	0.06	....	0.12
2	99.45	0.30	0.14	....	0.30
3	99.45	0.11	0.13	....	0.23

A screen analysis of the crushed sandstone, using the W. S. Tyler Standard Screen Scale, was also made and the results obtained from the same three samples follow:

PERCENTAGES RETAINED ON STANDARD SCREENS

	1	2	3
Remaining on 20 mesh	0.07	0.04	0.45
Remaining on 28 mesh, through 20 mesh	1.59	2.16	7.20
" " 35 " " 28 "	13.11	19.01	32.00
" " 48 " " 35 "	61.71	38.04	30.90
" " 65 " " 48 "	20.25	14.19	13.00
" " 100 " " 65 "	2.79	10.15	7.80
" " 150 " " 100 "	0.16	6.65	3.70
" " 200 " " 150 "	0.03	5.68	2.60
" 200 "	0.01	4.70	2.50
	99.72	100.62	100.15

The grains from each screen in analysis No. 3 above, were afterwards examined under a binocular microscope. Those remaining on the 35, 48, 65, and 100-mesh screens were found to have a rounded outline, with facets where the silica cementing them to adjacent grains had broken across. Those below this in size were angular. Over 50 per cent. of what remained on the 200-mesh screen were evidently fracture pieces. Apparently then this sandstone in crushing breaks across the cementing material between the grains, and not across the grains, and therefore yields round sand very like that from Ottawa, Ill. Moreover, the sandstone crushes readily to the sizes indicated above.

It is evident that the white sandstone of Potsdam age is eminently suited to the manufacture of high-grade glass, and for the manufacture of porcelain ware, pottery, earthenware dishes, floor tile, glazes, etc. The supply is unlimited and well situated for rail or water shipment, by the Canadian National railway or Rideau canal. The areas indicated on the map in yellow colour can be quickly run over, and suitable sandstone for any of the purposes required, and the location best adapted for shipment by rail or water, selected. The areas about Delta, Newboro, and Westport seem to the writer to be the most suitable.

Ordovician

The Ordovician sediments overlie the Cambrian sandstones with perfect conformity. The basal beds are shales, sandy limestones, and calcareous conglomerates, whose pebbles are largely quartz, indicating a very thorough disintegration and removal of all softer minerals from the pre-Cambrian rocks from which they were derived. These beds are about 8 feet in thickness, and are followed by a much more compact, finer-grained, dove-blue coloured series of limestones, remarkably free from fossils, and yielding a splendid compact building stone. In crushed form a good road metal for macadam construction is also obtained. This series is about 30 feet in total thickness. No horizon later than the Black River group was observed in the county of Leeds, and if any did exist it has been completely eroded away. The next material to be found above the Black River beds is the unsorted moraine of Pleistocene glaciation.

Glaciation and its Effects

At the close of this long period of time there were three relatively short stages of geological activity which bring us to the present. The first of these was the burial of all eastern Ontario, including the county of Leeds, beneath the Labradorian ice sheets. There is now ample evidence, about the margin of the ice-covered area, that there was more than one advance and retreat of the ice, with inter-glacial periods of considerable duration. In the county of Leeds itself, there is no evidence of these temporary retreats of the ice front.

The second geological event was a submergence of a large portion of eastern Ontario, including the southern part of Leeds, beneath the sea. This occurred towards the close of the Pleistocene epoch, that is, during the final retreat of the ice front.

The third and last episode brings us to the present. After the retreat of the ice, the area slowly rose again from beneath the sea, bringing the Thousand Islands region to its present altitude.

Discussing the first of these three events, we find everywhere the evidence of a great glacial movement from the Labradorian heights, east of Hudson bay, in a southwesterly direction, and extending to the northern part of the United States. Great deposits of till or soil made up of indiscriminate mixtures of clay, sand, silt, gravel, and boulders are found overlying well polished, smoothened, scratched, and gouged rock surfaces. Every trace of decayed or weathered rock has been scraped off, and a fresh surface presented to the renewal of weathering processes. Ordinarily on areas that have not been glaciated, the soil is not marked off sharply from the rocks on which it rests, but shows a gradual passage from surface soil, downward into less and less altered or disintegrated rock, to fresh rocks at the base of the section. The soil is a residual soil left, by the processes of weathering, on the rock from which it was formed. In glaciated areas, on the contrary, the soil bears no relationship to the formations beneath it. It is made up of fine to coarse materials, clay, sand, gravel, and boulders, many of which have no known outcrop for many miles from the place at which they are found. The whole mass is usually quite without any signs of sorting or stratification.

There is no actual means of telling how deep was the layer of residual soil which covered the rocks of this area before the advance of the Labradorian ice sheet, but from the fact that the area was exposed from Silurian times onwards, we might conclude that the residual soil was very deep, and it is extremely doubtful that the pre-Cambrian rocks of this district were exposed, till bared by the Labradorian ice sheets. The many outliers of Paleozoic sediments strongly suggest that they covered all this portion of Ontario previous to the advance of the ice. The writer has described the structure of the pre-Cambrian, and accounted for its topography as being the result of erosion on a series of harder belts of intrusive igneous rocks, with softer belts of schists, gneisses and crystalline limestone. The whole structure was developed northeast and southwest into ridges and valleys, due to differences in the hardness of the rocks involved. The ice movement was, therefore, forced to take this general direction from the Labradorian highlands. When it reached the Paleozoic sedimentary area, its direction of movement was already well established, as is evidenced by the parallel striation and gouges developed on the smooth sedimentary rocks. This is strikingly brought out on the map accompanying this report. The tongues or peninsulas of sediment, as they project southwest from the general area, are most striking, and show that they occupy the pre-Cambrian hollows. Corresponding projecting fingers of the pre-Cambrian rocks in a northeasterly direction, mark the axes of ridges between the depressions filled with Paleozoic sediment.

Lying upon the rock surface, we find a variable thickness of unconsolidated material. Three formations are recognizable, and mark broadly the three episodes spoken of above. The deposits of the first and oldest period are irregular bodies of glacial drift, composed of calcareous clay for the most part, but mixed in many places with sand, gravel or boulders. This represents ground moraine deposited by the glacier with little or no sorting. The greatest advance of the Labradorian glacier was well beyond the southern boundary of the State of New York and northern Pennsylvania. During the slow retreat of the Ontarian lobe of the ice-front, the ponded waters about its front were first drained off through the Mohawk valley of New York State. By further retreat of the Ontarian ice-lobe, the drainage developed farther north in the vicinity of Rome, New York, and later still the ice-lobe retreated sufficiently to allow the overflow of the great glacial lake, lying at the ice-front, to take place around the Adirondack region of New York State, and out by Covey Hill to the Champlain drainage basin.

During all this time the county of Leeds was deeply buried beneath glacial ice, so that none of the re-sorted, laminated clays collected in and about these great lakes were deposited in this county; only the unsorted ground moraine was left here. From Covey Hill, which lies near the boundary between New York State and the Province of Quebec, the land drops away to the St. Lawrence valley, but this was still blocked by ice, and it was only much later, and by further retreat of the ice-front, that the St. Lawrence valley was opened up, and the level of this large glacial lake fell to the then sea level. It was a very different sea level from that of the present time. The finding of marine shells as far up the St. Lawrence as Prescott and Brockville proves that, despite the volume of fresh water entering from the great glacial lakes about the ice front, salt water extended up at least to these places. Up the Ottawa valley, marine shells are similarly found ten miles above the city of Ottawa, and in the county of Leeds the remains of whales were found near Smith Falls. With the opening of the St. Lawrence valley, therefore, and the entry of the sea water to about the eastern end of Lake Ontario, we reach the second stage in glacial deposition in and about the county of Leeds.

Almost everyone in Canada is familiar with the typical glacial drift, and particularly with the boulders or "hard heads" which in so many localities have to be picked up and removed from farming lands. In Leeds there is the usual collection of rounded boulders or rocks from the more northeasterly parts of Ontario. There is an abnormally large percentage of flat flag stones, which represent portions of the Paleozoic sedimentary rocks, torn off and carried along in the basal portions of the ice.

The invasion of the sea just described backing up the upper St. Lawrence river close to Lake Ontario, has been given the name of Gilbert gulf, and it is clear that many of the lower valleys of Leeds county would be occupied by bays of brackish water in which re-sorted glacial drifts would tend to be deposited as well sorted gravel, sand, or bedded clay, depending upon the strength of the current present. This second member of the glacial period is therefore frequently a laminated clay of striking appearance. It consists of a series of thin bands of rich clay, with alternate bands of marly clay or sometimes sandy clay laid in perfect conformity. At the time these banded deposits were laid in the waters of Gilbert gulf, the water level must have stood about 400 feet higher than at present, for geologists of the United States have shown that the beaches of Gilbert gulf, in the vicinity of Waterdown, N. Y., are now about 733 feet above the sea, that is, 487 feet above Lake Ontario. Much of the county of Leeds lies below this level, and remnants of these beds lie in nearly horizontal position almost everywhere. These clays are remarkably free from boulders and pebbles although such are occasionally found, and are believed to be due to droppings from floating ice in Gilbert gulf.

Loam is defined as an intimate mixture of clay and sand, and as many of these laminated clays are interbanded with sandy material, the ploughing of such areas yields the finest of loamy land, and the farmers of Leeds county distinguish very readily their clay land, from their loamy land. During the past abnormally dry season, the loamy land held its moisture so much better than the clay lands that remarkable contrasts in crop could be seen in adjoining fields, or even more strikingly in portions of the same field.

With the final retreat of the glacial ice, and the consequent removal of its great weight, the northeastern portion of Canada began to slowly rise, so that the sea level sank towards its present position, and the St. Lawrence river with its Ottawa tributary developed. Thus the county of Leeds and adjoining areas were soon exposed to the action of weathering and erosion, which has continued to the present time. Along its drainage channels, and in its lower flats alluvial plains were formed. In its lakes re-sorted and bedded sediments are now forming. On its shallow swampy lands, peat beds or marl beds have accumulated, and in many places wind-blown dune sands have collected.

About a mile east of Clark station, on the Canadian Pacific railway, and about seven miles north of Brockville, is a group of sand dunes which overlie the glacial drift. This sand is light pink in colour, and the hills are bare, so that the blown sand is destroying roads and much of the agricultural land in their vicinity. An effort is now being made to clothe them with small pine trees, and areas have been planted in the hope of binding the sand together, and stopping its drifting to adjoining territory. The success of the attempt cannot be told yet, as the planting is too recent.

As mentioned above, local deposits of marl and peat are now forming in the lower marshy areas. The largest of these peat bogs lies about three miles due north of Brockville. It is about one mile wide, and nearly three miles in length, and its longer axis lies as usual about northeast. These deposits make up the third, and most recent group of accumulations of unconsolidated character, and bring us to the present time.

Summary of Economic Minerals

The chief economic features of the area have been dealt with under the various formational divisions in which they occur, but a recapitulation of them here may not be out of place.

The Grenville formation yields crystalline limestone, too coarse for marble, but suitable for lime burning, and for road metal on less travelled roads. The material is too soft, however, to be used where traffic is heavy.

The Grenville gneisses are much used in crushed form for road building, and produce a very good material, especially when rolled in with finer top dressing.

Some graphite and galena are found in the crystalline limestone, but no accumulations of possible economic value were seen in this county. Many small seams of "black lead" or graphite are found amongst the crystalline limestones, but they could not be considered from an economic standpoint.

The Laurentian gneisses are suitable only for road metal in crushed form. Along their contact with crystalline limestones, or with highly calcareous gneisses, is favourable ground for deposits of amber mica suitable for electrical insulators, boiler packing, fire proofing, etc.

Algoman granites and syenites yield the very finest of building blocks, monumental or decorative stone, and paving blocks.

The pegmatitic phases of this formation yield economic deposits of feldspar, suitable for glazing purposes, or in their less pure form for pottery, porcelain, toilet ware, electric insulators, glazed or unglazed ware, floor-tile, etc.

The Keweenawan traps would be the most suitable rocks possible in crushed form for road metal, but are not present in sufficiently large quantity to offer much encouragement in this respect.

The coarse-grained gabbroic members are often associated with magnetite, which carries nickel in most cases, but unfortunately always carries titanium also, which up to this time has caused these ores to be refused by the iron smelter. Recent investigations would indicate that electrical smelting offers some prospect for the use of these ores in the near future.

The Potsdam sandstones are suitable for building stone in rich red to buff colours. The white coloured highly siliceous ones are suitable for road metal, and paving blocks, and the writer suggests their investigation by glass manufacturers, and also by manufacturers of porcelain earthenware, or other products requiring the so-called "flint" of commerce in their process.

The Ordovician is suitable for lime-making, for building stone, and in crushed form for macadam road building.

Unconsolidated glacial drift yields local deposits of gravel or sand for road building, and for concrete mixtures, while local beds of clay, free enough from pebbles, are used in the manufacture of building brick and common field or drain tile.

The following note[1] on iron smelting in the county of Leeds is of historic interest:

> The first iron furnace in this Province was erected about the year 1800 in the northern part of the township of Lansdowne, in the county of Leeds, at the falls of the Gananoque river. The ore used was of inferior quality and had to be drawn a considerable distance, and after two years' trial the enterprise was abandoned. An attempt was made to cast such hollow-ware as pots and kettles for the use of settlers, but that also proved to be a complete failure.
>
> The furnace was erected by a company composed of Ephraim Jones, Daniel Sherwood, Samuel Barlow and Wallace Sutherland, and the location was known as Furnace Falls, now Lyndhurst. In the Geological Survey report for the year 1851-2 Alexander Murray states that the ore[2] used was a "scaly red ore," and was obtained on lot 25 of the 10th concession of Bastard, "but the quantity in the locality worked was not sufficient to give a profitable result."

---

[1] Report of Royal Commission on the Mineral Resources of Ontario, 1890, p. 319.

[2] *See* reference on page 16 under Iron Ores.

INDEX

Vol. XXXI, Part VI.

PAGE

Acknowledgments 1
Age classification of rocks of area (table) 2, 3
Algoman 10, 11, 24
Alumina 19
Analyses:
  Glass sands used in United States 19, 20
  Gneiss (Grenville) 6
  Gneiss (Laurentian) 8
  Iron ore, Chaffey and Matthews mines 15
  Quartzite (Grenville) 5
Animikie 14
Apatite 9, 10

Baker, M. B. 1*n*
Bastard tp., iron ore 16
Biotite 10
Black River group 20
Breccia 6, 7
Brockville 22, 23
Brown, A. C. 13
Building stone 17, 18

Calcite 9
Calcium phosphate 9
  See Apatite.
Cambrian 16-20
Canadian National Railway 20
Chaffey mine, South Crosby tp. 15
  Iron ore analysis 15
Charleston lake.
  Laurentian intrusives 8
Chemical Products Company, Limited of Trenton, Ont. 9
Chrondrolite 4
Clark station, Canadian Pacific Ry. 23
Cleveland, Ohio 15
Cobalt (mineral) 15
Covey Hill, New York State 22
Crystalline limestone (Grenville) 3, 4, 23
Cushing, Dr. 10, 12

Delta 20
Diopside 4

Feldspar 10, 11, 12
Furnace Falls. *See* Lyndhurst.

Galena 23
Gananoque 8
Gananoque Junction 8
Gilbert gulf 22, 23
Glaciation and its effects 20-23
Glass sands, analyses 19, 20
Gneiss (Grenville) 7, 23
  Analysis 6
Gneiss (Laurentian) 8, 24
Gordon, Charles 13

PAGE

Granite for building uses 13
Graphite 4, 9, 23
Great War Veterans' Memorial Monument, Lyndhurst 13
  Photo ....*Frontispiece*
Greig, J. W.
  Quoted on sandstone for glass-making 18, 19
Grenville 3-7, 23

Hematite 4
  South Crosby tp. 17
Hornblende 10

Ingall, E. D. 1*n*
Iron ore,
  Analyses, Chaffey and Matthews mines 15
  Bastard tp. 16, 24
  Smelting at Lyndhurst 24

Jones Falls 8

Keewatin 3
Keeweenawan 14, 15
Keeweenaw Pt., Lake Superior 3
Keystone Works, Pennsylvania Glass Sand Co. 19
Kingston, Ont. 10, 18
Knight, C. W. 3, 10

Lansdowne tp. 24
Laurentian 7-10, 24
Logan, Sir William 9
Loughborough tp., apatite 9
Lyndhurst.
  First iron furnace in Ontario 24
  Memorial monument. . . *Fontispiece*, 13
Lyndhurst Granite Quarries 13

Magnetite 24
Manganese dioxide 19
Mapleton, Penna. 19
Maps (former) of area 1
Matthews mine, North Crosby tp.
  Iron ore analysis 15
McNeill, W. K. 6*n*, 8
Military Surveys Branch, Department of Militia and Defence 1
Miller, W. G. 3, 10, 15
Mohawk valley, New York State .. 22
Mica 8, 10
Murray, Alexander 24

Newboro 20
Newboro lake.
  Laurentian rock belt 8
Nickel 15
North Burgess tp.
  Apatite mining in (1868) 9
North Crosby tp. 15

PAGE

Ontario Department of Highways .. 1
Ordovician 20, 24
Ottawa, Ont. 22
Ottawa, Ill. 19, 20
Ottawa valley, marine shells 22

Paving blocks 18
Pegmatite dikes 11, 12
Pennsylvania Glass Sand Co., ... 19
Phlogopite (mica) 4, 9
Phosphate 9
Picton granite 10
Pittsburg tp., Frontenac co., ... 19
Pittsburg, Penna. 15
Potsdam sandstone 16, 17, 19, 20, 24
Prescott 22
Price, apatite (1868) 9
Pyroxene 9

Quartzite (Grenville) 5

Rideau canal 20
Rideau Mining Company 9
Rocks of the area,
  Age classification 2, 3
Rogers, W. R. 1
Rome, New York State 22
Royal Commission on Mineral Resources of Ontario 1, 24*n*

Sand lake, Laurentian intrusives 8

PAGE

Sandstone. *See also* Potsdam sandstone.
  For building 17, 18, 24
  For glass-making 18, 19, 24
Scapolite 9
Silica 18, 19
Smith Falls, Leeds co. 22
South Crosby tp. 8, 15
  Hematite deposit 17
  Iron ore analyses 15
  Laurentian rock belt... 8
Sphene 10
Syenites 10, 24

Thousand Islands region 1, 21
Topography 2

Vennor, H. G. 9
Vesuvianite 4

Waterdown, New York 22
Wedron White Sand Co., of Ottawa, Ill. 19
Westport 20
Whitefish lake 13
Woodburn Granite Quarries, Gananoque 13
W. S. Tyler Standard Screen Scale . 19

Yonge Mills
  Laurentian rock belt 8

Zircons 10

PROVINCE OF ONTARIO
DEPARTMENT OF MINES

HON. H. MILLS, MINISTER OF MINES THOS. W. GIBSON, DEPUTY MINISTER

THIRTY-FIRST ANNUAL REPORT

OF THE

ONTARIO DEPARTMENT OF MINES

BEING

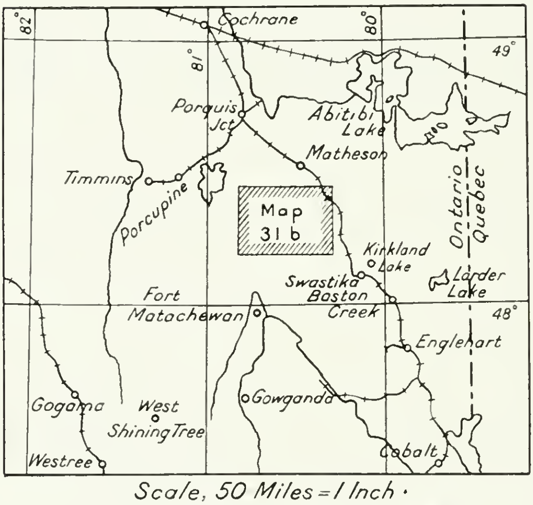
VOL. XXXI, PART VII, 1922

Geology of the WATABEAG AREA

By Douglas G. H. Wright

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY OF ONTARIO

TORONTO
Printed by CLARKSON W. JAMES, Printer to the King's Most Excellent Majesty
1922



Key map showing location of the Watabeag Area (Map No. 31d.)

CONTENTS

Vol. XXXI, PART VII.

Page

Introduction 1
Previous Work 1
Acknowledgments 2
Means of Access 2
Topography 3
Drainage 4
Waterpowers 5
Timber 5
Agriculture 6
Geological Outline 6
  Keewatin 7
  Algoman 11
  Cobalt Series 15
  Matchewan 15
  Pleistocene 18

Page

Economic Geology 18
  Iron 18
  Copper 19
  Molybdenite 19
  Erythrite (Cobalt Bloom) 19
  Gold 19
Brief Summary of the Townships
  Playfair township 22
  McCann township 23
  Tolstoi and Terry townships 23
  Lee township 24
  McEvay township 24
  Nordica township 25
  Egan township 25
  Sheraton township 26
  Michie township 27
  Timmins township 27

ILLUSTRATIONS

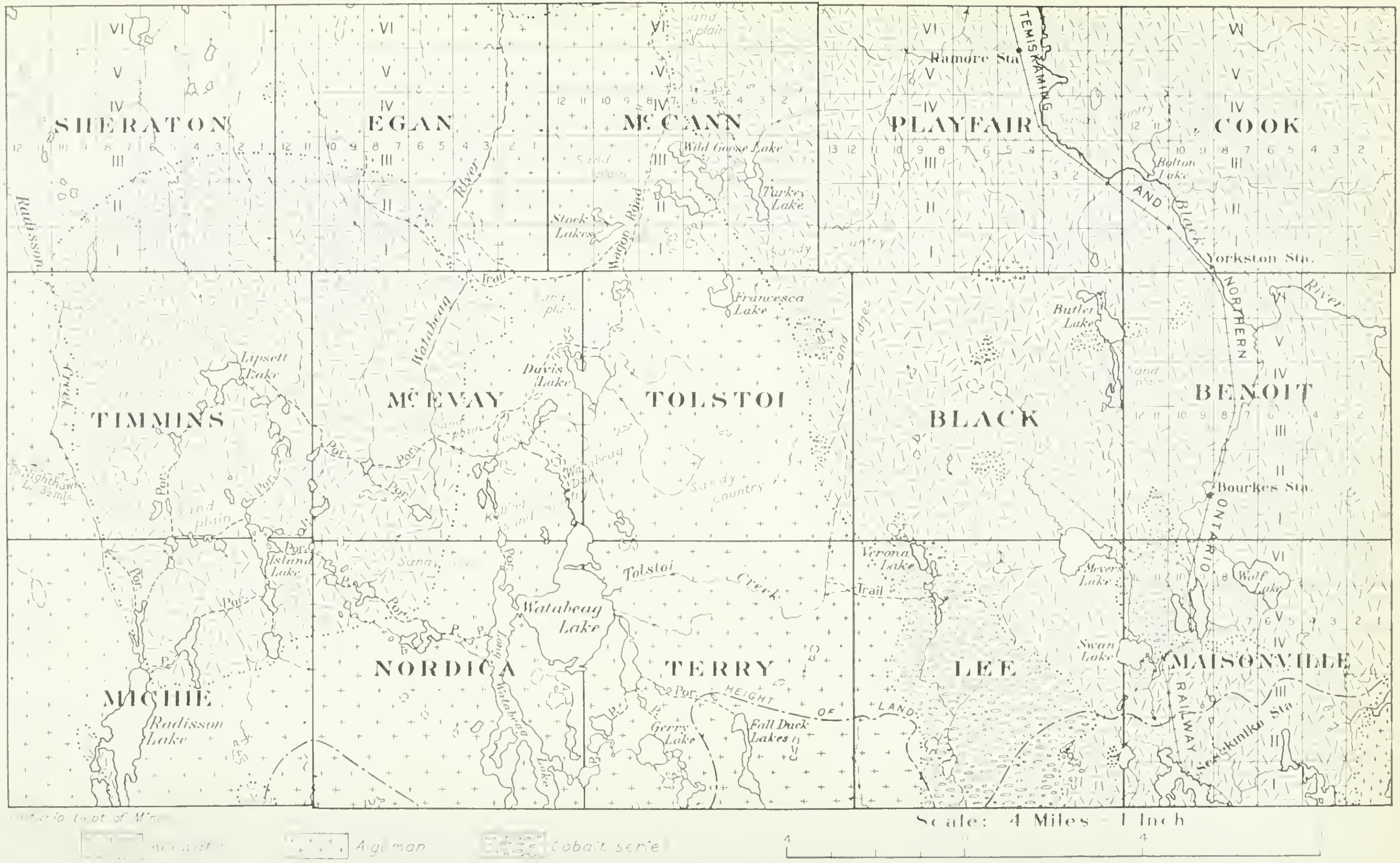
Looking east from west bank of the Black river near Ramore towards Lava Flow Mountain, Cook township. The country was devastated by the Matheson fire in 1916. 3
Waterfall on the Black river, south half lot 3, concession V, Playfair township. 4
Psuedo-conglomerate, lot 1, concession V, Playfair. The hammer rests upon a rounded boulder of pink-weathering feldspar porphyry 8
Psuedo-conglomerate, lot 1, concession V, Playfair. 9
Foliated Keewatin schists containing lenticular-shaped masses of greenstone, situated on the northeast shore of Radisson lake. 9
Pillow lava near Ramore station, north half lot 4, concession V, Playfair. 10
Contact shatter breccia showing rounded xenoliths partly assimilated and surrounded by a hybrid rock. McCann township, lot 7, concession V. 14
Slate-like greywacké member of Cobalt series near 4½-mile post, north boundary of Lee township. The cleavage is perpendicular to the bedding, signifying that the outcrop is near the axial region of a fold. 16
The Black river in Playfair township flows between high clay banks. The view shows the west bank of the river, in concession IV, thirty feet high. Note the stratified clay in the upper part underlain by till. 17
Lemoine lake, Nordica township, typical of the beautiful lakes so abundant throughout the rolling sand country. View looking northwest across the lake from Hill lake portage. 25
A three way contact near the east shore of Saral lake, Timmins township. Fresh diabase, instrusive through Keewatin hornblende schist, and pink-weathering hornblende-feldspar porphyry of Algoman? age. The feldspar porphyry is the light coloured rock in the upper right hand corner of the picture. Contacts have been accentuated with white chalk 29

KEY and INDEX MAPS

Key map, showing location of the Watabeag area (Map No. 31d.) .... (ii)
Index map showing the extent of Algoman granite and syenite, also Keewatin rocks. Only the larger areas of Cobalt series are shown. The two lower tiers of townships are in the distict of Timiskaming, while the top tier forms part of the new district of Cochrane, created October 2, 1922. .... (iv)

GEOLOGICALLY COLOURED MAP

No. 31d—Watabeag Area, Districts of Cochrane and Timiskaming, scale 1 mile to the inch. .... *(In pocket on inside of back cover).*



Index map of Watabeag Area, showing the extent of Algoman granite and syenite, also Keewatin rocks. Only the larger areas of Cobalt series are shown. The two lower tiers of townships are in the district of Timiskaming, while the top tier forms part of the new district of Cochrane, created Oct. 2, 1922.

GEOLOGY OF THE WATABEAG AREA

Districts of Timiskaming and Cochrane

By Douglas G. H. Wright

Introduction

The Watabeag Lake area comprises the townships of Lee, Terry, Nordica, Michie, Timmins, McEvay, Tolstoi, Black,[1] Playfair, McCann, Egan and Sheraton.

The area is contiguous on the west to the Black River area mapped by the writer in 1920 and, as will be seen from the key and index maps, is favourably located with respect to other areas, either of proven worth or of good promise as gold camps. The Porcupine gold area lies to the northwest and that of Kirkland Lake to southeast. To the northeast is the Beatty and Munro gold area and to the southwest lies Matachewan, with deposits of promise. From the fact that Watabeag[2] lake extends into four of the twelve townships of the area and because the basin of the Watabeag river includes more than one half of the area, the name Watabeag seems a suitable one for the report. The height of land between the valley of the St. Lawrence and the Hudson Bay slope passes along the south of the area. The southeast quarter of Lee township and a southern portion of Terry township lie to the south; the remainder of the area is north of the height of land.

The area is roughly four hundred and fifty square miles in extent, and of this almost four hundred square miles were covered during the summer of 1921. Hence it will be realized that the following report must only be treated as a geological reconnaissance of the area, supplemented by more detailed work in localities where geological conditions, or considerable staking, warranted it.

Travel routes were surveyed, micrometer and prismatic compass being used on lake surveys, and pace and compass traverses on portages. The various township boundaries were used as control lines. In the townships which had not been subdivided it was necessary to run pace and compass traverses following as a general rule the diagonals of the township. In subdivided townships lot and concession lines were travelled and claim lines in staked territory. Following the plan instituted by C. W. Knight[3], the dotted courses on the accompanying map, No. 31*b*, show these inland sections so that prospectors may know what parts were examined.

The rock classification used on the accompanying map is largely a field one, based on the megascopic characters of the rocks.

Previous Work

The first geological work in the Watabeag area was done by George F. Kay in 1903. Mr. Kay examined the rocks along the old canoe route to Fort Matachewan, which traverses the chain of lakes through the centre of McCann township, and also rock outcrops on Watabeag lake and along the Watabeag river, from which he also ran several inland sections. The result of Kay's work was published in the 13th Report of the Bureau of Mines, 1904. Since the available supply of this report is limited, some of the more important passages have been quoted herein. Later W. M. Goodwin prospected a part of the area between Gowganda and Porcupine, and a geological sketch map, compiled by him, was published by the Department.[1]

---

[1] Black township has been taken from the Black River Area to complete the block. Ont. Dept. Mines, Vol. XXX, Part 6, 1921.

[2] The writer was informed by Wasil McDougall, an Indian trapper, that Watabeag, translated, means "Northern Lights lake."

[3] Map of Ben Nevis Gold Area, Ont. Dept. Mines, Vol. XXIX, Part 3, 1920.

Acknowledgments

The thanks of the Ontario Department of Mines are due the R. S. Potter Lumber Company, of Matheson, for the many courtesies extended the party while working in the area, and also to the Abitibi Power and Paper Company of Iroquois Falls for the map of Watabeag lake.

The field party consisted of one graduate assistant, J. W. Dougherty, three undergraduate assistants, W. Greenwood and J. C. Macgillivray, of Queen's University, and F. L. Hutchison, of Toronto University, and the writer. Most of the inland sections were done by dividing the party and working in pairs, Mr. Dougherty taking one assistant and the writer the other. Mr. Dougherty must therefore be credited with a large share of the field work.

Means of Access

The Temiskaming and Northern Ontario Railway traverses the townships contiguous on the east, crossing into the Watabeag area along the eastern boundary of Playfair, near the second concession. The eastern townships of the area present individual problems in accessibility, and these will be dealt with later under the heading of the township concerned. The western three-quarters of the area may be reached by the canoe route which follows the old Fort Matachewan trail. This route, however, is not recommended for travel, as it has not been used in recent years. An alternative route is to go by wagon road from Matheson to Davis lake, on the Tolstoi-McEvay boundary, and from there follow the Blackwater-Lockpot lake route to Watabeag lake. From Watabeag lake there are various canoe routes which may be seen on the accompanying map. Practically all portages shown were travelled by our party during the summer of 1921, and were recut and reblazed where necessary. Many of the portages follow sand ridge or sand plain country, and though some of them are quite long the travelling is good. The trip to Watabeag lake may also be made by ascending the Watabeag river from its junction with the Black river as far as the creek outlet of the Davis lake system; but the current throughout the trip and the many log jams encountered make the journey both toilsome and irksome, and hence teaming of canoes and supplies to Davis lake, if not to Watabeag dam, is recommended. The area is also accessible from Nighthawk lake by way of a three-and-a-half mile portage to Radisson (Trout) creek in Timmins township.

The Watabeag Dam road starting from Matheson is suitable for motor car traffic as far as Blackwater lake. Light cars have completed the trip to the dam. During the summer of 1922 the Abitibi Power and Paper Company, Ltd., improved the road from Blackwater lake to the dam, so that motor cars may now make the through trip.

---

[1] Map of part of the area between Gowganda and Porcupine, accompanying Vol. XX, 1911, Part 2, Ont. Bur. Mines Report.

Topography

Much has already been written on the general aspects of various areas comprising the pre-Cambrian Shield region, and a detailed topographical description would be largely a repetition. Topographically, the area exhibits a monotonous undulating landscape, broken occasionally by low, rocky hills, which rise to elevations of only a few hundred feet above the surrounding country. Locally, the country is quite rugged, particularly in the eastern part of McCann township, in the Radisson and Island lake vicinity.

There are extensive sand plain areas, low and rolling, diversified by kettle holes, eskers and an occasional rocky ridge, usually composed of the more resistant rock types, granite and post-Algoman diabase. Plains of another type, not formed by outwash from the glacial ice sheets which overran the country, but caused by the silting in of lakes, are well exemplified in several instances, particularly in Timmins township, stretching north from Dougherty lake, and in Nordica township about the centre, stretching westward from Watabeag lake. Plains of this type are usually ear-marked with ponds which represent the lower declivities of the central portion of the former glacial or post-glacial lake basin.

Looking east from west bank of the Black river near Ramore towards Lava Flow mountain, Cook Township. The country was devastated by the Matheson fire in 1916.

Another striking topographical form is that assumed in localities underlain by sediments of the Cobalt series. Such areas are characterized by valleys and ridges running north and south. The Cobalt series has been gently folded along north and south axes, and the more jointed and broken anticlinal portion has been obliterated by erosion, the synclinal portion forming a ridge. A striking example of this may be seen in the north-south ridge commencing immediately west of Cariad lake in Black township and continuing southward into Lee township, to the west of the chain of lakes which drain into Tomwool creek.

Lakes are numerous, varying in size from mere ponds to those having areas of several square miles, such as Radisson[1] and Watabeag. The water is usually crystal clear, and practically free from organic matter in suspension. Lakes are most common in the sand plain country.

---

[1] There are numerous Trout lakes throughout northern Ontario and for this reason it was deemed advisable to change the name. Radisson was one of Canada's early explorers who discovered the Great North West, ten years before Marquette and Joliet, twenty years before La Salle and a hundred years before De la Vérendrye.

Drainage

The Black river and its tributaries, the White Clay, the Watabeag, the Wildgoose, the Driftwood and their respective creek affluents, drain all of the area excepting the southeast corner of Lee, a small southern portion of Terry township, which lies to the south of the height of land, and the western parts of Michie, Timmins and Sheraton townships which lie west of a secondary divide. Streams in the area west of this secondary divide drain to Hudson Bay through the Nighthawk system, one of the main tributaries of the Moose river. Radisson (Trout), the main creek in this part, is a tributary of the Whitefish river, joining the latter at a point in Thomas township one-and-one-half miles west of the two-mile post on the western boundary of Sheraton. Cautts creek, one of the main creek tributaries of Radisson creek, has its source in Cautts lake. Cautts lake is fed by an underground stream, Mackay creek, which drains Stewart and Mackay lakes and the area east of Radisson lake in Michie township. The point where Mackay creek becomes a subterranean stream was not seen by the writer. That it does follow a course beneath the surface, is commonly known to sojourners in this locality, and this was confirmed by our inland sections. The bottom of Cautts lake appears as numerous springs, and there is a heavy deposition of marl.

Waterfall on the Black river, south half lot 3, concession V, Playfair township.

All the rivers are quite young, possessing V-shaped valleys, and many rapids and falls. Numerous swamps exist, due to the drainage not being well established.

Waterpowers

Small waterpowers might be developed at several points within the area. On the Black river in Playfair township there are two falls, one of about twenty feet in the northwest corner of the north half of lot 2, concession II, and the other with a level difference of approximately 30 feet in lot 3, concession V. On Wildgoose river in the north half of lot 8, concession V. of the same township, there is a falls of 40 or 50 feet already harnessed. The power developed is utilized for operating a small saw mill.

In Lee township, on White Clay creek there is a small, picturesque falls having a drop of twenty feet.

On the Watabeag river there are two falls of note, one in McEvay, slightly north of the centre of the township, the other, called Egan chutes, which is north of the Egan-Currie boundary, just beyond the limits of the area herein described. The first-mentioned is a very pretty falls, at the head of which the river narrows to about fifteen feet, then widens as the foaming waters plunge over the rocky ledges. A hundred yards below this falls the river forms a chute. The total drop, including rapids above and below the falls, is roughly sixty feet. At Egan chutes the water tumbles over a rocky ledge at about forty-five degrees with a level difference of thirty feet. There are points of vantage on the Watabeag river where inexpensive dams might be constructed to permit the storage of almost any desired quantity of water in the Watabeag lake system.

Timber

The area is well forested, but large tracts have been burnt over several times, until in some townships mere remnants only are left of the once green forest. This is particularly true of McCann, Tolstoi and Playfair townships. The timber of economic importance consists of poplar, balsam, spruce, jack (banksian) pine and minor quantities of white pine. The white pine has a fairly profuse distribution around Watabeag lake. Poplar is abundant along the banks of the Watabeag river and in Lee township. The greater portion of the area is sandy: hence jack (banksian) pine is the most abundant.

Forest fires have devastated considerable of the area in recent years. Playfair township was swept by the Matheson fire in 1916. The central portion of McCann is burnt bare. Tolstoi township is largely brulé. Forest fires were active during the long, dry spell in 1921, and swept the eastern part of McCann and the western part of Playfair. During the same period the central and northwestern part of Egan township and the southern portion of Nordica, lying west of Watabeag lake, were devastated by fire.

The western part of the area has not been much travelled in recent years, nor have forest fires devastated it to any extent; as a result wild animals are still fairly plentiful. Moose are numerous, red deer and bear are occasionally seen. The fur-bearing animals are gradually becoming extinct, although beaver are still plentiful. Most of the lakes are well stocked with fish: pike, pickerel, trout and whitefish being the most common species. Watabeag lake fairly teems with lake trout, and in addition to this is a most picturesque spot, readily reached by motor car from Matheson over a good stage road. The lake is an ideal summer camping spot with few rivals in natural grandeur. The sand beaches, with shelving lake bottoms, are splendid for bathing. The trout fishing is unexcelled in northern Ontario. Game in the vicinity of Watabeag lake is still plentiful. The water is transparently clear, as the translation of the Indian name implies. The average depth is thirty-five feet and the maximum sixty-four feet.

The Watabeag basin comprising Main Watabeag, Long Watabeag, Link and Caribou lakes, lies partly in all of the following townships—Nordica, Terry, McEvay, Tolstoi and Sheba.

TABLE OF ACREAGES OF WATABEAG BASIN.

Township	Approx Area
Terry	940 acres
Nordica	838 "
Sheba	77 "
McEvay	59 "
Tolstoi	57 "

The topography of the locality is that of a rolling sand country, with numerous hills and ridges. Sand ridges parallel the lakes, extending in most instances to the water's edge. The stratified sand bluffs, thirty to forty feet high, on the north shore of main Watabeag, near the narrows, and on the east shore, south of the Caribou system inlet, are extremely picturesque. The timber is practically all green, the area having been burnt over about forty years ago. Jack or banksian pine is the dominant species. The jack-pine forest is diversified by small numbers of birch, poplar and white pine, the latter, towering majestically above the surrounding forest. There are several islands, one of rock in the main lake and three small gravel islands and a large sand island in Long Watabeag. From Watabeag lake many side trips may be taken. The portages, for the most part, lead through sandy country which ensures a minimum of hardship in portaging. A good stage road from Matheson to Watabeag dam, on the Watabeag river, renders the locality easily accessible by motor car.

All in all, this centre of natural beauty is warmly recommended to the "back to nature" lover during the summer months.

Agriculture

Excepting the township of Playfair, which is essentially a farming community, only small areas are suitable for agricultural purposes. The soil varies from light to heavy clay and, judging from the crops during the summer of 1921, is quite productive. Other localities suitable for agricultural purposes are in McCann, Egan and Sheraton townships.

Geological Outline

In general the geology of the Watabeag area is similar to that of other component parts of the pre-Cambrian shield, and more particularly to those lying within the boundaries of Timiskaming district. A summary of the geology giving a classification of the rocks according to age relationships, used in this report and on the accompanying map, is given below. The rock formations are in order of age, the oldest being at the bottom of the table.

PLEISTOCENE.	
GLACIAL AND RECENT	Fluviatile and lacustrine deposits of stratified clay and sand, gravel, boulders and till, mostly of glacial origin.
	Great Unconformity.
PRE-CAMBRIAN.	
KEWEENAWAN (Nipissing)	Quartz, diabase and olivine diabase occurring as dikes and sill remnants.
	Intrusive Contact.
ANIMIKEAN (Cobalt Series)	Conglomerate, greywacké, argillite, slate-like greywacké, arkose.
	Great Unconformity.
MATACHEWAN	Dikes, frequently characterized by the presence of numerous phenocrysts of labradorite feldspar sometimes 1 and 2 inches in diameter.
	Intrusive Contact.
ALGOMAN (?)	Granite (gneissic in places), syenite, porphyries, aplite and lamprophyre dikes.
	Intrusive Contact.
KEEWATIN	Rhyolite, andesite, basalt, volcanic fragmental, pseudo-conglomerate, old diabases and gabbros, meta-basalt, hornblende, chlorite and sericite schist.

The oldest rocks of the area are of Keewatin age. These rocks are largely basic to intermediate volcanics, and their schistose derivatives. The Keewatin in places has been liberally intruded by acid dikes and a batholith of granite and syenite which are probably of Algoman age. The post-Keewatin rocks have been intruded by dikes of diabase, for the most part quite fresh-looking and frequently characterized by large phenocrysts of labradorite having a greenish colour and a waxy lustre.

Following the intrusion of the diabase was a long period of erosion, after and during which a series of flat-lying sediments, the Cobalt series, was deposited upon the eroded surface of the older basic volcanic and granitic rocks.

No diabase dikes were observed intruding the Cobalt series, but doubtless some of the diabase is of Nipissing age, although considerable of it is thought to be post-Algoman and pre-Cobalt in age. The intimate association of some of these diabase dikes with the granite masses suggests that there may be some consanguinity between the two.

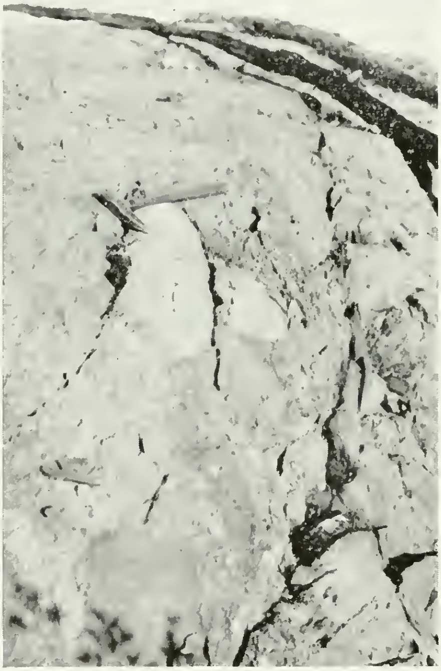
Keewatin

The Keewatin rocks in the area are considered to represent an orderly succession of lava flows, basic for the most part. Rock types identical with the Cook township lava flows[1] were traced westward across Playfair into McCann township but the structure was worked out only in lot 3, con. III, of Playfair township where five distinct flows were recognized, tilted up from the horizontal to an almost vertical position. The strike of the upturned edge of the flows is S. 81° E, magnetic. Amygdaloidal and pillow lavas have a widespread distribution, and in several other localities remnants of distinct flows were recognized. One exposure, easy of access, is in the north half of lot 4, concession V, of Playfair township, a few chains east of Ramore post office. Keewatin rocks in the eastern part of the area, remote from the batholithic intrusion of granite, are fairly massive, and show comparatively small signs of dynamic metamorphism, whereas the Keewatin rocks in proximity to the granitic intrusion have been largely altered to hornblende, chlorite and sericite schists. The most common strike of the schists is between north and west and the dip is usually 60°—70° northeast; some variations to this have been noted on the accompanying map.

---

[1] The Black River Area, Ont. Dept. Mines, Vol. XXX, 1921, Pt. VI.

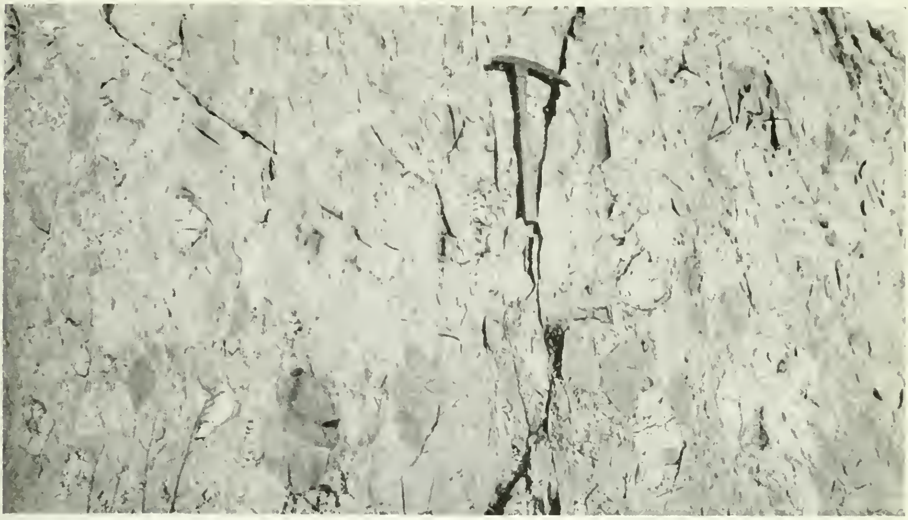
Excellent exposures of pillow lava occur throughout Playfair and McCann. Associated with these are bands of volcanic fragmental material, fine-grained and agglomeratic in character, which doubtless represent tops of flows, the structure being obscured by the overburden.



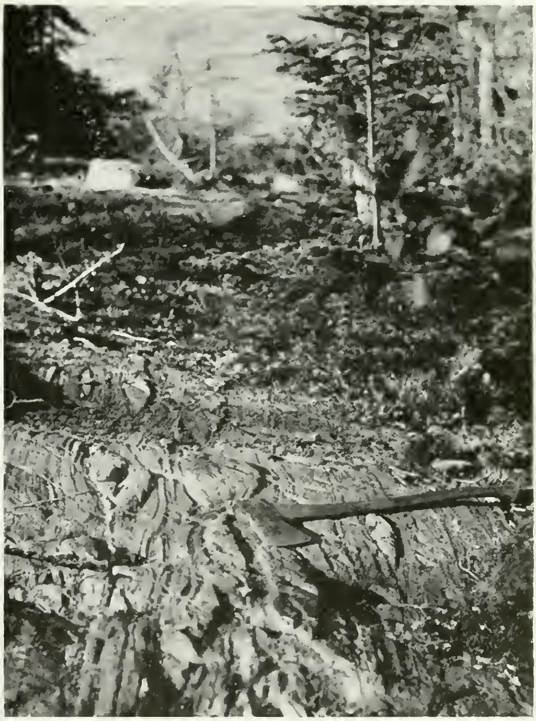
Psuedo-conglomerate, lot 1, concession V, Playfair. The hammer rests upon a rounded boulder of pink-weathering feldspar porphyry.

In the northeast corner of Playfair there are some interesting small exposures of a pseudo-conglomerate. The matrix is quite schistose, the strike being South 60° East magnetic and dip 75° to the south. The pebbles and boulders are of various kinds, elongated parallel to the schistosity and ill-assorted. Boulders up to two feet in diameter are alongside of small stones, from a few inches to a fraction of an inch in diameter. Pebbles of the following were noted—pink granite, feldspar porphyry, basalt, dolerite and amygdaloidal lava. An outstanding feature is the large proportion of granite and pink-weathering feldspar porphyry. Many of these pebbles have been well rounded.

This pseudo-conglomerate seems to be infolded with basic lava flows classed as Keewatin. Under the microscope the matrix appears to be igneous with small



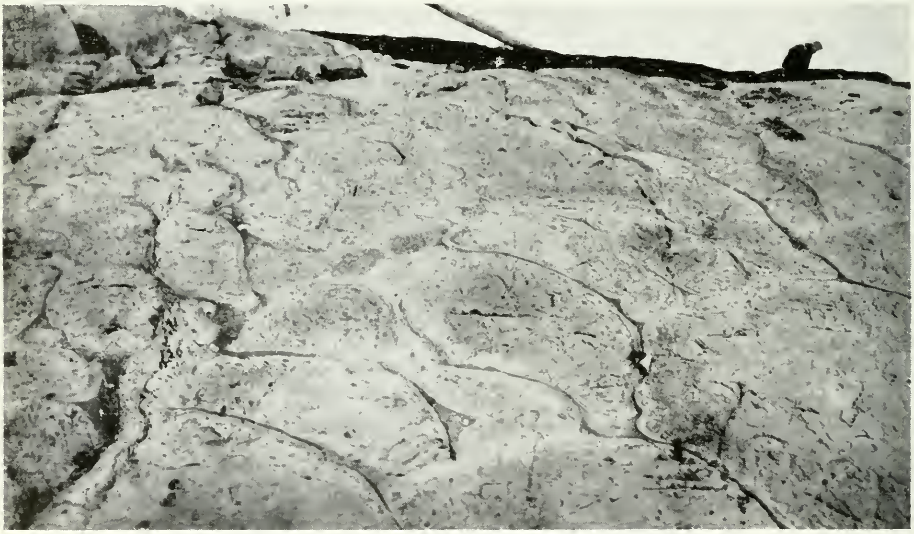
Psuedo-conglomerate, lot 1, concession V, Playfair.



Foliated Keewatin schists containing lenticular-shaped masses of greenstone, situated on the northeast shore of Radisson lake.

crystals of quartz and feldspar in abundant chlorite. The outcrops are small and field relationships obscure. Although these rocks resemble in some respects sediments of Timiskaming age, definite proof of sedimentary origin is lacking. Hence they have been classed tentatively as Keewatin. The possibility, however of these schistose clastics being an infolded remnant of the Timiskaming series must be considered, since these rocks occur in Munro township to the north and east. The outcrop bears a strong resemblance to rocks occurring in lot 5, con. 1, Tisdale township, southwest of the Dome mill, and these have been classified by Burrows[1] as Timiskaming.

The Keewatin schist, which surrounds the granite and syenite batholithic intrusion, varies quite locally from black glistening hornblende to chlorite to sericite schist, the first-named being the predominating type. The schist usually has a banded or foliated structure, owing to the parallel alignment of the rod-like crystals of hornblende and infiltration of feldspathic materials in the planes of schistosity. Every occurrence of amphibolite or hornblende schist was in the marginal zone surrounding the intrusive batholith. In many instances a gradation from these schists to typical volcanic types could be traced. In several localities the amygdaloidal structure was preserved, notably in the hill outcrop north of the Sylvia-Sanborn lake portage in Nordica township, and in lot 9, concession II, Egan township. The relationships of these foliated schists indicate that they were all originally volcanic rocks that have been re-crystallized and foliated through the contact action of the intrusive granite batholith. The strike of the schists was found to parallel in a general way the periphery of the intrusive batholith.



Pillow lava near Ramore station, north half lot 4, concession V, Playfair.

On the accompanying map many occurrences of dolerite have been noted. Since this is a general term, it will be defined for the purpose of this report. The word dolerite, as used, covers that class of rocks which range chemically from a diorite to a gabbro, megascopically lacking the ophitic texture characteristic of the diabase, and too fine-grained to definitely show, in hand specimens, whether the predominant ferro-magnesian mineral constituent is pyroxene or hornblende. Rocks of this type have a widespread distribution in the area, and represent to a great extent the central portion of the lava flows.

---

[1] Ont. Bur. Mines, Vol. XXV, 1915, Pt. 3, map No. 24*e*.

Grey lavas and more acidic volcanics, such as rhyolites, are not widely represented in the Keewatin volcanic complex of the area. In several localities acid rocks were noted. The island in the Black river just below the twenty-foot fall, concession IV, Playfair, is composed of acid volcanics. Another occurrence is with the Keewatin schists along the shore of the southwest bay of Radisson lake.

The alteration of the Keewatin rocks, other than the metamorphic effects of the granitic intrusion already mentioned, consists largely in the development of such secondary minerals as chlorite, serpentine, quartz, carbonate, feldspar, epidote, sericite and kaolin. The secondary minerals developed, and the relative proportion of each, depend upon and vary with the original rock type. The ferro-magnesian minerals usually alter to chlorite and epidote. Alteration to serpentine, where observed, was only local and usually along joint planes.

Keewatin rocks west of the eastern boundary of the granite-syenite batholith in general consist of island-like masses, which are considered to be remnants of the original roof of the batholith.

The Keewatin of the Watabeag area has been closely folded. The lava flows have been tilted up from the horizontal into an almost vertical or sometimes a slightly overturned attitude. The axial strike of the folds is always from north 83° east astronomic to due east and west. The axial strike in the Watabeag area is practically identical with that determined for the Keewatin of the Abitibi[1] and the Black river[2] areas to the east.

Algoman

The central portion and western fringe of the area is occupied by a granitic batholith with syenite porphyry facies. Some of the granite is quite similar to rocks farther south referred to as Laurentian.

Certain writers have drawn an arbitrary age line, depending upon whether the dark-coloured constituent of the granite is biotite or hornblende, others have used gneissic textures as a criterion for separating the granites, usually allocating the gneissic granite to the Laurentian. The writer's field experience, however, failed to show these criteria applicable. Practically all of the granites contain both hornblende and biotite, although the former is admittedly the predominant dark-coloured acessory mineral, and gneissic texture is common. The development of gneissic texture is always local and appears to be due to conditions existing during solidification, rather than to regional deformation which would naturally affect the entire mass rather than isolated portions of it.

In the Watabeag area, it was not possible to get any erosive unconformities or igneous contacts between the granitic rocks and older rocks of post-Keewatin age.

Granites of the Laurentian should be, in most cases, more decomposed and disturbed than Algoman granites.

---

[1] Ont. Bur. Mines, Vol. XXVIII, 1919, Pt. II.

[2] Ont. Dept. Mines, Vol. XXX, 1921, Pt. VI.

For the reason that there appears to be no grounds for separating the granites of the area, and, further, as the rocks are comparatively fresh and undisturbed, with one exception to be cited later, they have all been tentatively classed as Algoman.

The granite and syenite is intrusive into the Keewatin and is older than the Cobalt series. The conglomerate of this series is composed largely of boulders and pebbles of reddish hornblende granite and a syenite porphyry identical with the rocks seen *in situ*.

The index map shows the probable extent of the granite batholith. The Keewatin in McCann and Egan townships in proximity to the batholith has been intimately intruded by narrow granitic dikes.

The granite batholith of the area, herein described, is in all probability a part of a huge batholith which extends southward into Robertson, Sheba, Dunmore, Holmes[1], Alma and Cairo[2] townships.

In McCann township, along the Watabeag road, are outcrops of hornblende syenite porphyry. It was observed that the proportion of hornblende increases towards contact with the Keewatin. The syenite porphyry in both Egan and McCann townships is extremely coarse; lath-like phenocrysts, three-quarters of an inch long, are common. In lot 8, concession IV, McCann township, phenocrysts 3 inches long were seen. The porphyry is of a deep pink shade and weathers to a pale pink. Some of the feldspar exhibits zonal weathering. A partial analysis made by W. K. McNeill, Provincial Assayer, of the syenite porphyry from lot 8, McCann township, along the line between concessions IV and V, gave soda 8.66 per cent., potash 3.85 per cent. The feldspar phenocrysts consist of plagioclase and microcline. The plagioclase was proven by means of its index of refraction and extinction angle to be albite. Feldspar forms a high percentage of the rock.

The major occurrences of the coarse albite syenite porphyry are confined to the township of Egan and McCann. In the remainder of the area covered by the granitic batholith the rock type is usually rather syenitic granite with biotite and hornblende as accessories, together with minor quantities of sphene, apatite and zircon. The granite grades without change in texture to hornblende-albite syenite or quartz-albite syenite. In places the former syenite consists of about equal proportions of light coloured minerals and of dark ferromagnesian minerals. The light pink feldspars usually have a pearly cleavage surface.

Kay[3] made rather an exhaustive petrographic study of the syenite exposed on on the island in main Watabeag lake, and his findings are quoted, in part, below:

> Perhaps the most interesting of all the rocks of the area were collected on a small island in Wataybeeg Lake. Two quite distinct types were found, one of which has been called a hornblende-albite syenite, the other a quartz-albite syenite.
>
> The hornblende-albite syenite is a medium-grained phanerite, the individual grains having a diameter of about one millimetre. This rock consists of about equal proportions of light-coloured minerals and of the dark ferromagnesian minerals. The light colored minerals are feldspars, no quartz being present. The feldspars have a pale

---

[1] Cooke, H. C., Exploration of the townships west of Kirkland Lake, Can. Geol. Survey, Summary Report 1919, Pt. E, and Geology of Matachewan District, Can. Geol. Survey, Memoir 115.

[2] Burrows, A. G., The Matachewan Gold Area, Ont. Dept. Mines, Vol. XXVII, 1918, Pt. 1, and the Matachewan Gold Area Ont. Dept. Mines, Vol. XXIX, 1920, Pt. III.

[3] Kay, George F., The Abitibi Region, Ont. Bur. Mines, Vol. XIII, 1904, Pt. I.

pinkish color, pearly cleavage surface, and in patches they exhibit poikilitic effects. The ferromagnesian minerals are hornblende and biotite, the former predominating. In thin section, the prevailing texture is poikilitic; but certain parts present a somewhat graphic texture, due to the interlocking of the crystals; the only constituent, other than the accessory minerals, which approaches automorphism is the hornblende.

The feldspars consist of a plagioclase feldspar and microcline. The plagioclase feldspar was proven, by means of its index of refraction and angle of extinction, to be albite. The albite and the microcline assume several relationships; in some cases, the microcline is poikilitic in the albite; in some cases, the opposite is true, that is, the albite is poikilitic in the microcline; again, the two minerals are coarsely intergrown, in which case an approach to graphic texture is presented, but further examination shows that the two minerals have a parallel arrangement, and hence the texture is really coarsely microperthitic; the albite and the microcline appear to have grown contemporaneously.

The microcline usually shows polysynthetic twinning, that is, lamellar twinning according to the albite and pericline laws.

The albite is also twinned, although many of the crystals are so cut that the striations are not apparent; the prevalent twinning is according to the albite law, but a few Carlsbad twins were also observed. The striations of the albite are very narrow and straight. Of the two feldspars, the albite has suffered the greater amount of decomposition, although both are comparatively fresh.

The hornblende usually occurs in irregular crystals, although automorphic forms in sections cut across the prisms also occur; in such cases the characteristic cleavage is quite perfect. The pleochroism is from a light greenish-brown to green.

The biotite occurs in irregular shaped plates. Its color is brown. The ferromagnesian minerals are poikilitic in the feldspars; both the biotite and the hornblende are somewhat altered.

The subordinate minerals are sphene, which occurs in orange-yellow irregular crystals, and apatite, which is quite abundant in well-formed prisms, some of which are colored by iron oxide. The secondary minerals are a fibrous, light-colored hornblende, which is probably actinolite, a light-colored chlorite and calcite.

An analysis of this rock by Mr. A. G. Burrows, of Belleville, Ont., gave the following result:—

	Per cent.
SiO_2	56.62
Al_2O_3	16.33
Fe_2O_3	trace
FeO	4.21
MgO	7.65
CaO	5.12
Na_2O	4.34
K_2O	2.68
TiO_2	.26
CO_2, H_2O, etc.	2.70

Measurements were made of the minerals present in this rock and the mode determined.[1]

The result was as follows:

	Per cent.
Albite	27.80
Microcline	17.54
Biotite	11.15
Hornblende	42.45
Apatite	.73
Titanite	.29

With these percentages an attempt was made to ascertain what must be the nature of the hornblende to correspond with the composition of this rock as determined by analysis. In this calculation the biotite was assumed to have the composition of the biotite in a quartz monzonite from Walkerville, Butte, Montana.[2]

It was found that the hornblende must be high in silica, high in alumina, high in magnesia, low in iron and low in potassium. A hornblende from Sanlupe was found to have such a composition.[3]

The quartz-albite syenite is found associated with the hornblende albite syenite, the two types seeming to grade into each other. Megascopically, this rock differs considerably from the associated rock, in that it consists almost entirely of light-colored minerals, there being less than five per cent, of ferromagnesian constituents. This rock is also different in that it contains quartz, while mica is absent.

---

[1] Quant. Class. of Igneous Rocks, p. 204.

[2] Table XIV. Quant. Class. of Igneous Rocks.

[3] Dana: System of Mineralogy, page 395.

In thin section, the texture is seen to be similar to that of the hornblende-albite syenite. The feldspars are albite and microcline, which present the same characteristics as were described in the associated rock, but whereas in the hornblende-albite syenite there was less than twice as much albite as microcline, in this rock the albite is about six times as abundant as the microcline.

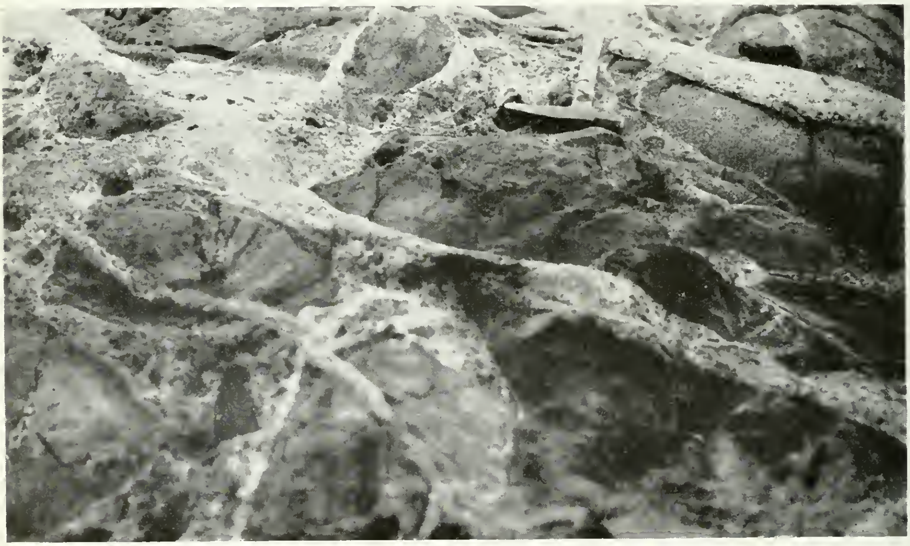
The quartz comprises about 13 per cent. of the rock. It is clear and has xenomorphic outlines. It is usually segregated in small patches.

The ferromagnesian mineral is hornblende, which has a rather deep-green color and constitutes about 5 per cent. of the rock. It shows the usual pleochroism, and in some crystals the characteristic cleavage is present.

The accessory minerals are sphene, apatite, zircon, and a small amount of magnetite.

This rock was also measured and the percentage weights determined. The result was as follows:—

	Per cent.
Albite	69.86
Quartz	13.55
Microcline	11.91
Hornblende	4.26
Apatite	.03
Titanite	.29
Zircon	.06



Contact shatter breccia showing rounded xenoliths partly assimilated and surrounded by a hybrid rock. McCann township, lot. 7, concession V.

In Playfair township, usually in close association with granite or syenite intrusions, a rock occurs which is composed largely of hornblende and biotite, separately or combined with an occasional small crystal of light pink feldspar, standing out in contrast to the darker minerals.

A study of a suite of specimens from the Mobb claim, 1187, northeast quarter of the south half of lot 9, concession IV, revealed evidence of consanguinity between this and the hornblende-albite syenite. In fact, some specimens collected are identical with hornblende and biotite albite-syenite, seen on the island in main Watabeag lake. These rocks were therefore mapped with the Algoman and are considered lamprophyric differentiates from the granite magma. The biotite melaphyre or minette type is of common occurrence among the Playfair lamprophyres.

The only point where the Keewatin-granite batholith contact is well exposed for any distance is in McCann township, where an interesting hybrid facies has been developed. Contact shatter-breccias, showing both angular and rounded xenoliths, are in evidence in the hybrid zone, together with a true hybrid, formed by the digesting of the wall rock by the molten magma prior to solidification. The inclusions or xenoliths are in many instances comparatively unaltered, and their parent rock may be readily determined. The xenoliths range in size from minute fragments to blocks with major axes of 10 to 15 feet, or even larger. The largest are comparatively scarce, the greater number being 2 to 6 feet in diameter, with numberless smaller ones.

Quartz veins in the area covered by the granite-syenite batholith should be carefully prospected for gold, since the deposits of this metal in Cairo and Alma townships, occur with quartz veins in the syenite, presumably a part of the same batholith.

The possible exception of granite of an earlier age than Algoman, previously referred to, is a dike 15 feet wide of schistose granite, with a strike of north 20° west magnetic and an almost vertical dip, which occurs on the east shore of Radisson lake, just north of the southern boundary of Michie township. This dike can be traced to the western shore of the lake, and on account of its appearance it is considered to be possibly of pre-Algoman age.

Cobalt Series

Since all the rocks of the Cobalt series have been fully described by W. G. Miller[1] and others in recent publications of the Department, the writer will refrain from entering on a detailed description of the Cobalt series in the Watabeag area.

Sediments of this series are found mainly in the central portion of Lee township, in the eastern part of Tolstoi township, and in the southeast corner of McCann township. In Lee township, to the west of Verona, Burl and Tomwool lakes, a narrow ridge striking N. 15° W. extends north into Black township. The direction of this ridge outcrop appears to represent the main axis of a fold, for the cleavage is almost perpendicular to the bedding. The dip of the strata rarely exceeds 20°, and is almost invariably to the east.

No younger rocks intrusive through the Cobalt series were found in the Watabeag area.

Matachewan Series

The Keewatin rocks, and the granite and the syenite of Algoman (?) age, are cut by dikes and small masses of fresh diabase. Many of the dikes consist of a coarse quartz diabase frequently containing phenocrysts of labradorite feldspar, sometimes one or two inches in diameter. The phenocrysts have a greenish-yellow, waxy appearance, due principally to sericitization and kaolinization. A coarse porphyry of this type may be seen on the hill outcrop on the northeast shore of Sanborn lake in Nordica township.

---

[1] W. G. Miller, Cobalt and Adjacent Areas, Ont. Bur. Mines, Vol. XIX, Pt. II, 4th Edition.

Besides the porphyritic diabase, there are two other varieties, one an olivine diabase, the other olivine free. The olivine diabase is characterized by spheroidal weathering and in certain instances, notably on the outcrop north from the Toy-Sanborn lake portage, residual boulders may be seen.

At the close of the season, the writer collected a suite of specimens from Diabase hill in the Cobalt area for comparison, and both microscopically and megascopically these rocks appeared identical with the post-Algoman diabase of the Watabeag area. In the field, however, some of the diabase had an older appearance than the Nipissing diabase of the Cobalt area. As no diabase was found cutting the Cobalt series in the Watabeag area, none of it is definitely determinable as Nipissing diabase. An intimate association between the diabase dikes and the granitic masses was noted in the field, which strongly suggests a genetic relationship between at least some of the diabase and the Algoman (?) granites and syenites of the area. Burrows[1] noted an instance where several dikes of fresh diabase lie unconformably below the basal conglomerate of the Cobalt series, and Cooke[2] reports that conglomerate of this series includes boulders of the diabase. Many of the diabase dikes of the Watabeag area are

Slate-like greywacké member of Cobalt series near 4½-mile post, north boundary of Lee township. The cleavage is perpendicular to the bedding, signifying that the outcrop is near the axial region of a fold.

---

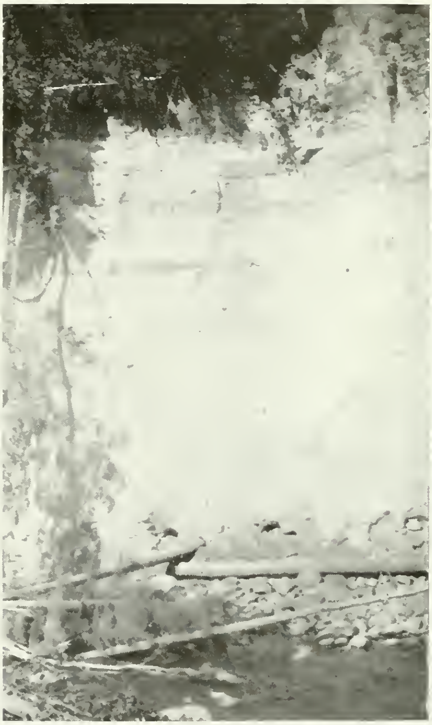
[1] The Matachewan Gold Area, Ont. Bur. Mines Report, Vol. 27, 1918, Pt. I, page 229. Gowganda and other Silver Areas, Ont. Dept. Mines Report, Vol. XXX., Pt. III., 1921, p. 8.

[2] Geology of Matachewan District, Geol. Sur. of Can., Memoir 115, p. 33.

considered to be the correlatives of the diabase of the Matachewan area to the south, the age of which, as has been pointed out, was definitely affixed as post-Algoman and pre-Cobalt. Separation of these diabases, post-Algoman and pre-Cobalt, and Nipissing, on petrographic grounds would indeed be difficult if not impossible. Therefore the strong possibility of some of the diabase being the correlative of the Nipissing diabase must be considered.

In the vicinity of Island lake, Michie township, some small isolated occurrences may possibly be sill remnants.

The contacts in the majority of cases were not exposed, but, to cite an instance, on the east shore of Island lake a sill remnant of a fresh diabase appears to rest unconformably upon the eroded surface of the Keewatin schists.



The Black river in Playfair township flows between high clay banks. The view shows the west bank of the river, in concession IV, thirty feet high. Note the stratified clay in the upper part underlain by till.

The dikes have a vertical attitude, or nearly so, and usually a northerly strike. The exomorphic effects of the diabase are unimportant, and only extend into the intruded rock a few inches from the contact.

Narrow alpite dikes and feldspar-porphyry dikes frequently cut the diabase. These are regarded as an acid facies of the latter. Dikes of this nature are to be seen on the hill outcrop west of the Watabeag river, on the north boundary of Egan township, and on the northeast shore of Wildgoose lake in McCann township.

Pleistocene

Superficial deposits of unconsolidated material cover a great part of the area. These drift deposits consist largely of sand, gravel, stratified clay, or sand and clay. The townships of McCann, McEvay, Tolstoi, Terry and Nordica comprise, in the main, one vast undulating sand area. Here and there are sand ridges and hills which stand out prominently above the surrounding country. Although the glacial trend in the area, as revealed by striæ, is about 10° east of south, the majority of the moraines and eskers have either a northwest and southeast or an east to west trend. The area presents many interesting glacial features which do not fall within the scope of this report, requiring as they do a detailed topographical study for proper and intelligent interpretation.

Economic Geology

Speaking generally, from an economic viewpoint the geological work proved disappointing, for much of the area is both overlain by swamps and sandplain and underlain by hornblende granite. The Keewatin rocks near the margin of the granitic batholith are favourable for prospecting.

Geologically, the area is more favourable as a possible gold producer than for any other mineral. Gold discoveries have already been made at several widely distributed points i nthe area, viz., in Playfair, in Terry, in Egan and in Timmins townships. These prospects will receive particular mention later.

Small deposits of fluorite have been found in Cairo and Alma townships in the eastern part of the Matachewan gold area.[1] They occur in quartz veins in syenite. Since the syenite of the Watabeag area is thought to belong to the same batholith, and owing to the widespread occurrence of fluorite in the area contiguous to the south, prospecting might be rewarded by the finding of economic deposits of this mineral. Small quantities of fluorite were seen in a quartz vein on the west shore of Radisson lake near the bay.

Barite veins of commercial importance have been found cutting the red syenite in one instance, and the Cobalt series slate and quartzite in another, in the Matachewan area. There is a possibility of making similar discoveries in the Watabeag area.

Iron

On the southern boundary of lot 12, concession II, Egan township, there is a small deposit of magnetite, with a minor quantity of chalcopyrite, occurring as a magmatic differentiate from the post-Algoman diabase. Some of the chalcopyrite exposed to weathering conditions is altered to the blue basic cupric carbonate, azurite. The outcrop at the point of concentration of the magnetite is quite small, but the diabase appears to underlie the whole lot and appreciable local attraction was noted in this locality. It was, therefore, deemed advisable to mention this occurrence, since differentiation from similar magma has in other areas yielded deposits of economic importance. Complementary dikes, further evidence of magmatic differentiation, were noted in the same locality. Several specimens taken from the outcrop were tested for chromium with negative results. Titanium is present.

---

[1] Burrows, A. G., Matachewan Gold Area, Ont. Dept. Mines, Vol. XXVII, 1918, Pt. I.

Copper

Copper-bearing minerals, principally chalcopyrite, were observed in numerous localities throughout the area, but in no place was a deposit of sufficient extent seen to be of commercial value. In the area chalcopyrite usually occurs in a quartz gangue as small aggregates or minute disseminations throughout the fresh diabase or aplite dikes, genetically connected with the diabase.

Molybdenite

Molybdenite was seen in a pegmatite dike in the granite on the Biederman claim, D.G. 67, on the south boundary of Terry township, and also on claim 17010 on the north boundary of Timmins township. The Timmins township occurrence is at the margin of a quartz vein 16 inches wide, striking S. 80° W., and dipping 60° north. In both instances cited the quantity of the mineral is small.

Erythrite (Cobalt Bloom)

Cobalt bloom was identified by the writer from a narrow calcite vein in proximity to the diabase dike which strikes in a northerly direction from the Radisson-Currie lake portage. The quantity was too small to be of economic importance, but at the same time it points to calcite veins in the vicinity of the diabase dikes and sill remnants being worthy of attention as possible sources of silver. This mineral, cobalt bloom, has to date in the Province of Ontario been associated with Keweenawan (Nipissing) basic intrusions, with which are also associated the silver, nickel, and arsenic of Cobalt, Ontario, and elsewhere in the Province.

Gold

Gold discoveries have been made at several points in the area, notably in Playfair, Timmins and Terry townships. The discovery of gold in Playfair township was practically the first in north-eastern Ontario. The Ontario Land Survey party working in Playfair township first noticed the occurrence in 1905, and the news soon spread. Claims were staked by Messrs. Mercer, Mobb, Legris, Tabicoe, Gould and others, early in the spring of 1906.

The discovery of gold in 1908 along the south boundary of Terry township in the Fall Duck lake vicinity led to a mild rush to that part of the area. This was known as the "Caribou rush" of 1909. Other gold discoveries have been made, but no work has been done in late years on any of the discoveries.

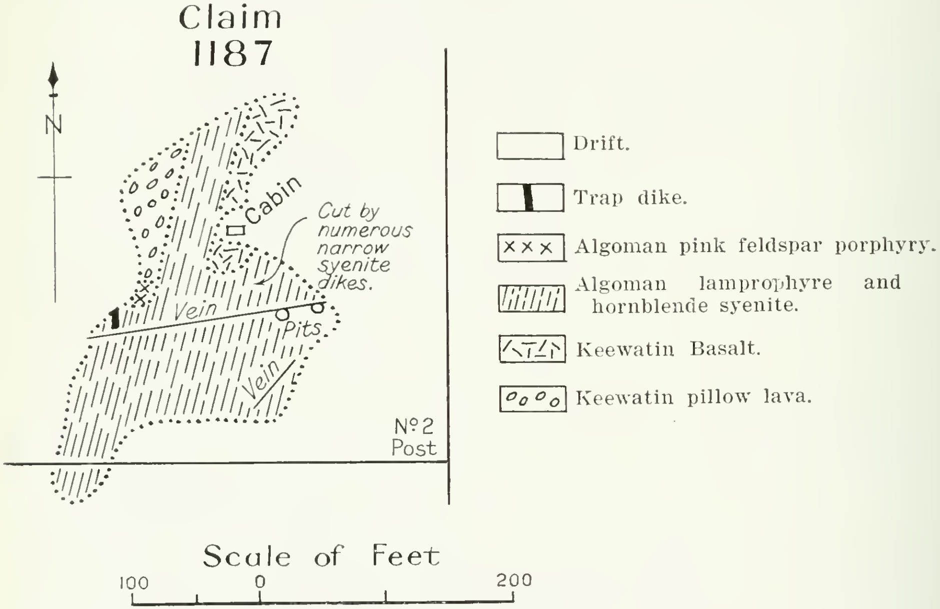
While the economic importance of the gold deposits so far discovered in the area is still quite problematical, they at least afford another striking example of gold being derived from acid intrusives of Algoman age.[1] This relationship is particularly well exemplified by the occurrence of gold in a pegmatitic vein in the granite on Biederman claim, D.G. 67, in Terry township. All gold discoveries to date, in the area, are in close proximity to the granite, syenite or feldspar porphyry, all of which are considered to have a genetic connection, being different facies of the same parent magma. In the proximity of these acid intrusions is a favourable locality to prospect for gold.

A few of the claims upon which gold has been found are now described:

---

[1] W. G. Miller and C. W. Knight in a paper entitled "Metallogenetic Epochs of the pre-Cambrian of Ontario," Transactions of the Royal Society of Canada, Series III, Volume IX, 1915, allocated most of the gold deposits of Ontario to the Algoman Metallogenetic epoch.

Mobb claim, 1187, is the northeast quarter of the south half of lot 9, concession IV, Playfair township. The rock outcrops are confined largely to the southeast portion of the claim. Two test pits have been sunk on the main discovery, which consists of three parallel veins that strike east and west magnetic, and dip almost vertically. The north and south veins consist of a quartz and calcite gangue slightly mineralized with iron pyrites, chalcopyrite and minor amounts of molybdenite. The centre vein is practically barren, and has tight walls, whereas the walls of the south vein are well defined. The wall rock on the north is a coarse-grained phanerite, a hornblende-albite syenite. This rock consists of about equal proportions of light-coloured minerals and of dark ferro-magnesian minerals. The light-coloured minerals are a plagioclase feldspar, albite and microcline with a pinkish colour and pearly cleavage. The ferro-magnesian minerals are hornblende and biotite, the former predominating. The rock is intimately cut by narrow pink syenite dikes, practically free from any ferro-magnesian minerals. Porphyry dikelets from one to a few inches wide cut the intervening rock between the north and south vein. The most easterly test pit has been sunk on the junction of this parallel vein system, and a barren, milky-white quartz vein striking northeast and southwest and dipping 45° northwest. The white quartz vein is paralleled by several narrow felsite dikelets, and is capped on the surface with magnetite. A chip channel sample on the parallel vein system taken across four feet on the most westerly test pit gave $60 in gold and 9 ounces in silver per ton. Values are erratic, however, as a second sample did not give such encouraging results. The owner, Frederick Mobb, having made an initial discovery of gold, was given a free grant under the Mining Act of Ontario. The patent to the property was not received until 1920, and nothing was done upon it from 1909, when the assessment work was finished, until the summer of 1920, when Mr. Mobb revisited the claim with a view to further testing it.


Claim
1187
N
Cabin
Cut by numerous narrow syenite dikes.
Vein
Pits
Vein
No. 2 Post
Drift.
Trap dike.
Algoman pink feldspar porphyry.
Algoman lamprophyre and hornblende syenite.
Keewatin Basalt.
Keewatin pillow lava.
Scale of Feet
100
0
200

Surface geology on Claim 1187. Some gold values are found in main east-west vein.

Biederman claims, D.G. 67 *and* 15740, are situated along the south boundary of Terry township near the two-mile post, and extend south into Dunmore township. The discovery was made in 1908, and a shaft was then put down to a depth of 20 feet on a quartz pegmatite vein, about 25 feet wide, cutting a pink granite, having biotite and hornblende as accessory minerals, the former being the more plentiful. The vein strikes S. 25° E. magnetic, and dips about 85° E. The footwall is obscure; the immediate hangingwall is a biotite melaphyre. The biotite melaphyre passes gradually into a pink biotite granite. The schistosity conforms with the strike of the vein. The central portion of the vein is barren, white vitreous quartz, with little gossan. Near the margin there is a patchy mineralization of iron pyrites, chalcopyrite and molybdenite. There is considerable feldspar with the quartz. A picked, heavily mineralized sample containing all of the minerals mentioned did not yield an encouraging assay in gold or silver.

A road was cut along the south boundary of Lee and Terry from Sesekinika lake in Maisonville township to the property. A diamond-drill outfit was taken in over this road in 1914, and several holes drilled by a prospecting company from New York. The writer is indebted to William Biederman, the owner, for the following particulars relative to the diamond drilling.

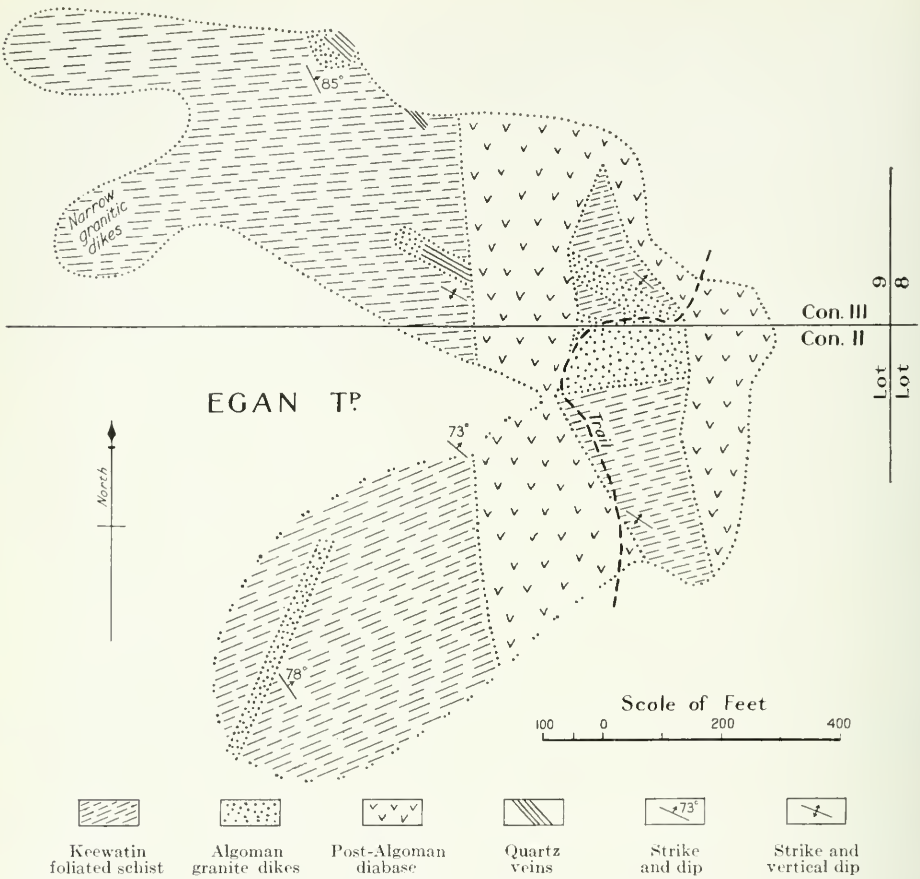
No. 1 hole	depth 125 feet	dip 75°
No. 2 hole	“ 320 feet	“ 85°
No. 3 hole	“ 269 feet	“ 60°
No. 4 hole	“ 300 feet, 10 in.	“ 60°

All holes were drilled from the footwall side of the vein. Values of 90 cents to $14 in gold and two to three ounces of silver per ton were obtained. All the assays were made of core from No. 3 hole, which was drilled 120 feet in quartz at an angle of 60°.

These values, while interesting, give no conception of the economic importance of the deposit.

Lightning River Gold Mines, Ltd.—This company owns four claims in Egan township, two patented, described as parcels 2443 and 2444, and two numbering 8499 and 8500, respectively comprising the south half of lot 9, concession III, Egan township. As will be seen from the plan on page 22, the discovery is near the Keewatin schist-granite contact. The main outcrop is near the centre of the four claims, and consists of Keewatin schists, hornblende and chlorite schist being the two prevailing types. The strike of the schist varies from east and west astronomic to N. 35° W. The dip is to the north and northeast at steep angles of 65 to 75 degrees. The Keewatin schists have been intimately intruded by narrow granitic, some porphyritic, dikes. The dikes have no regular strike, but in a general way it is parallel to the schistocity of the Keewatin. In the main outcrop there is a sheeted zone slightly over 100 feet wide and exposed along the strike for several hundred feet. The schists in this zone strike N. 37° W., dip 65° N.E., and are cut by a narrow quartz vein striking S. 53° E. The intervening rock and the quartz veins are slightly mineralized with cubical iron pyrites. The schists are locally altered to a ferruginous carbonate. There is a series of joint fissures at right angles to the main fracture. Grab samples, as nearly representative as possible, taken from sixteen different points across this sheeted zone, gave low gold values.

No work of any account has been done on the claims since 1916. During the summer of 1921 a cabin was built with a view to further prospecting the property.



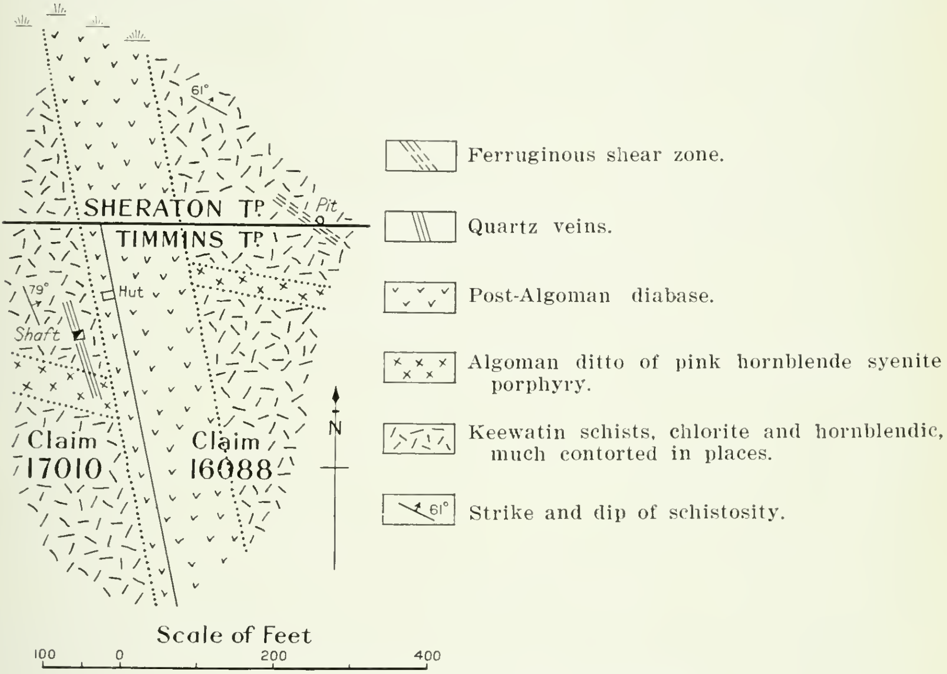
Claims of Lightning River Gold Mines, showing geological relationship of rocks typical of the Watabeag area. Small gold values were obtained from quartz veins cutting the granite.

Claims 17010 *and* 16088 are located along the north boundary of Timmins township at the southwest corner of Egan township. Considerable surface work has been done on these claims and a shaft sunk, judging from the dump, to a depth of 25 or 30 feet, near the hornblende-syenite porphyry-chlorite schist contact, on several parallel veins striking N. 6° E. magnetic. The gangue is largely quartz with minor quantities of calcite, ankerite and a carbonate, probably brunnerite (carbonate of iron and magnesium) judging from its tan-coloured weathering. The veins are mineralized with cubical iron pyrites.

The quartz veins cut both the Keewatin schists and the syenite porphyry, but the mineralization is largely confined to that part of the vein lying outside the porphyry. South of the shaft there is a small schistose felsite dike intrusive through the Keewatin schists.

From a representative grab sample of the vein material, an assay of $10.40 in gold per ton was obtained. Gold was seen in several specimens found on the dump.

On claim 17010, near the southeast corner, a test pit 13 feet deep has been sunk on a white vitreous quartz vein striking S. 80° W. magnetic, and dipping 60° N. The mineralization is scant. Along the footwall side of the vein there is a belt varying from a few to 18 inches in width, which contains considerable molybdenite and ankerite. The hangingwall has been altered to a ferruginous carbonate. Judging from material on the dump, the vein is associated with a deep pink to red coloured felsite dike. This dike was not seen on the outcrop. The footwall rock, carrying considerable molybdenite, showed only a trace of gold.


61°
SHERATON Tp.
Pit
TIMMINS Tp.
79°
Hut
Shaft
Claim 17010
Claim 16088
N
Ferruginous shear zone.
Quartz veins.
Post-Algoman diabase.
Algoman ditto of pink hornblende syenite porphyry.
Keewatin schists, chlorite and hornblendic, much contorted in places.
61°
Strike and dip of schistosity.
Scale of Feet
100
0
200
400

Geology of parts of Claims 17010 and 16099.

A speck of gold was seen in a narrow dike composed of dark aphanitic rock cutting a granitic boulder. The boulder was along the south boundary of Lee township, just west of the five-and-a-half mile-post. From the angular nature of the boulder and its many associates, and from the fact that the granite was identical with that seen *in situ* a few chains east, it doubtless was not transported far from the northward.

Panning of the glacial gravel and sand in the vicinity of Wolverton lake, in Timmins township, is reported to have yielded a few colours to the panful. Since the sand and gravel is purely of glacial origin, there is little chance of a natural concentration having been effected to a sufficient extent to form deposits of economic importance.

Brief Summary of the Townships

Playfair Township

The northeast quarter of Playfair township in traversed by the Temiskaming and Northern Ontario railway. Roads have been cut and graded in all but the southwest quarter of the township. Hence all parts are easily accessible. The greater part of the township is overlain with a heavy mantle of clay soil, well adapted for agricultural purposes. The arable lots are practically all taken up, and already there are many well improved farms. As a result of the Matheson fire in 1916, much of the land was easily cleared, and Playfair township now presents a well-settled appearance, and an uninterrupted view of the undulating clay land may be had across several concessions.

Ramore village, along the T. and N. O. railway, in concession V, is a thriving community. The village had, in the summer of 1921, a post office, two general stores, a bank, two restaurants, a boarding house, a blacksmith shop, three sawmills, a public school, a separate school and a Roman Catholic church. In growth this village rivals some of the western prairie towns, for it has been built up since 1912, when the first farm settlers came in.

The present postmaster, T. E. Cocklin, has been a resident of Ramore since 1908, before the township was thrown open for location. In 1908 Ramore was called Wildgoose siding. In February, 1909, a post office was opened at Ramore station as Clay Belt post office, a name afterwards changed to Ramore. The greatest influx of settlers came between 1914 and 1918, and it was not till following the Matheson fire in 1916 that the community and town spread west of the railway.

The entire township is underlain with Keewatin, possessing all the characteristics of extrusive lava flows. Locally, this basement of volcanic rocks has been liberally intruded by acid dikes, granite and syenite, frequently porphyritic and lamprophyre dikes. A promising locality, worthy of further prospecting for ore deposits, is in lots 7, 8 and 9, concessions II, III and IV. The most rugged country is situated along the southern and western boundary line. A splendid view of the entire township may be obtained from the summit of Kempis mountain, on the eastern boundary line.

Small values in gold were obtained from quartz veins cutting the Keewatin rocks in the north half of lot 13, concession V.

McCann Township

Topographically, the township of McCann may be roughly divided into three parts. The eastern third is rugged and underlain with Keewatin rocks; the central third is a rolling sand country which strongly suggests recessional glacial material; and the western third may be separated into the south half, which is flat land more or less swampy, and the north half, which is undulating land with a good mantle of clay loam, suitable for agricultural purposes.

The central rolling sand plain area has been repeatedly burned over until it is quite bare. There are areas of good poplar in the northwest quarter and considerable spruce in the southeast quarter. Some small remnants of the original jack pine forest still remain in the southern part.

The northeast quarter of the township is particularly rugged, and forest fires have bared the rock. The Keewatin rocks in this section have been cut by numerous narrow dikes of Algoman age. There are many high, rocky hills in the northeast and also along the Keewatin-granitic batholith contact, which runs roughly north and south across the centre of the township. In the southeast quarter there are a few outcrops of the Cobalt series.

Small lakes are numerous in the sand-covered part of the township.

The Matheson-Watabeag Dam road crosses about the centre of the township from north to south.

The most promising localities for prospecting are accessible from De Courcey, Wildgoose and Turkey lakes. Some recent staking has been done in the vicinity of Andrew lake, on lot 7, concession VI.

Tolstoi and Terry Townships

The townships of Tolstoi and Terry may be described together, since geologically and topographically they are somewhat similar. In the main they are characterized by rolling sand plains with occasional areas of considerable extent of flat land, more or less swampy. The sand ridges have two general strikes, east to west and northwest to southeast. The country north of Tolstoi creek in Terry is mostly swampy.

The central portion of Tolstoi has been swept by forest fires, which have destroyed considerable of the jack pine forest, but quantities of splendid jack pine still remain. Only minor tracts of agricultural land exist, and these are confined to the eastern part. They are not of sufficient extent to warrant subdividing the township.

Tolstoi township is not easily accessible, and has been but little travelled. From the prospector's viewpoint there is little of interest, since the rocks are almost entirely covered. Only here and there do small outcrops of the underlying granite and syenite occur. A strip along the east of the township, one mile wide from east to west, is underlain by Keewatin rocks. The bedrock in the remainder of the township is inferred to be granite and syenite, cut by numerous dikes of fresh diabase. Some small outcrops of the Cobalt series conglomerate and greywacké are scattered throughout the eastern third of the township.

A canoe route, which can be readily followed upon the accompanying map, leading from Caribou lake, makes all parts of Terry township comparatively accessible. Tolstoi creek, if cleaned out, would be suitable for canoe travel, but in its present condition is not navigable. A rough road has been cut west from Sesekinika lake, Maisonville township, to mining claim D.G. 67, situated at the two-mile post on the southern boundary of Terry township.

The rock outcrops seen, which are by no means numerous, except in the eastern third of the township, consist wholly of granite and syenite cut by fresh diabase dikes. The occurrence of gold in a pegmatitic quartz dike cutting the granite has already been mentioned.

Lee Township

White Clay creek, which empties into Meyers lake, is navigable by canoe during high water, but in shallow water the swamp willows, which in many places overhang its banks, make travel tedious. This creek and numerous lakes render the township reasonably accessible. The forest is green, with the exception of a small area surrounding Sarsfield Lake and extending westward along the southern boundary. The entire township is well timbered, principally with poplar, spruce and jack pine. Lee township is part of a timber berth held by T. S. Woollings & Co., of Englehart. The only pulpwood cut so far is in the vicinity of Meyers lake, where the company has erected huts.

The surface of the area is mainly rolling in character. The southwest part is low and swampy and spruce-covered, the east and north consists of more elevated clay land timbered with birch and poplar, and the southeast is a rolling sand country dotted with numerous small lakes of crystal clear water. A commanding view of the entire township may be had from the outcrop situated in the southeast corner of Terry township, a few chains west and north of the southeast corner. A feature of the topography is the north to south ridges of the Cobalt series.

The western fringe of the township is underlain by granite, the central belt by sediments of the Cobalt series, and the eastern portion by Keewatin rocks.

Some claims have been staked near the Lee-Maisonville boundary.

McEvay Township

McEvay township is well provided with means of access both by land and water. Wagon roads lead from the main Watabeag Dam road to the various camps along the Watabeag river. Most of these are shown on the accompanying map. The Watabeag river is quite suitable for canoe travel except during seasons when the timber drive is on.

The Watabeag river flows from south to north roughly across the centre of the township. The banks are high, in places 60 feet, composed of sand and gravel above the falls; below the falls, the soil is clay and clay loam and the timber along the banks changes from jack pine and poplar to spruce of merchantable grade. In the country lying to the east of the Watabeag river considerable valuable timber, mostly jack pine, has already been cut, but some patches of this pine of fine quality still remain, particularly along the Watabeag Dam road. West of the river practically no timber has been cut except along the river bank.

The entire township is covered with a heavy mantle of sand and gravel. Rock outcrops were seen only along the Watabeag river, and the northern and western boundaries of the township. Some rock, not definitely *in situ*, seen along the river between Lockpot lake and Watabeag dam has not been shown on the accompanying map.

Lakes are especially numerous in the southern half of the township. The northwest quarter consists of alternating sand and spruce swamp.

Many sand hills and ridges lend variety to the otherwise monotonous landscape. The usual strike of sand ridges is either east-west or northwest and southeast.

Lemoine lake, Nordica township, typical of the beautiful lakes so abundant throughout the rolling sand country. View looking northwest across the lake from Hill lake portage.

Nordica Township

Nordica is a township of varied topography, possessing as it does, rolling sand plain country, spruce muskeg and many high, rugged, rocky hills. The country between the three- and five-mile posts, along the western boundary, and that lying north and northwest of Sanborn lake, is particularly rugged. Rocky hills rise to elevations of one hundred and fifty feet above the surrounding country. A splendid view of the entire township may be had from the hill north of Sanborn lake. South from this point, the country gently rises for nearly two miles, the rise culminating in an east to west granite ridge, which crosses the township from Watabeag lake to the western boundary, about the three-mile post. North and south of this ridge is sand country with low knolls of rock protruding through the sand at widely separated points. Nordica township, excepting six or nine square miles in the northwest, is inferred to be underlain by granite and syenite. The area in the northwest is presumably underlain by Keewatin rocks, as all of the few outcrops seen were composed of hornblende and chlorite schist, metamorphosed sheared basic eruptives of the Keewatin series. These had invariably been cut by numerous narrow dikes of fresh diabase, as well as by a few acid dikes belonging to the Algoman intrusives.

Splendid canoe routes render all parts reasonably accessible. Watabeag lake, which is a feature of the township, has already received mention.

Egan Township

Egan township is one of the subdivided townships of the area. The land in general may be classed as undulating clay loam, except in two or three sections where rocky hills rise to an elevation of 200 to 400 feet above the surrounding country. Fifty to sixty per cent. of the land is suitable for agricultural purposes. The greater part of concession I is unsuitable for settlement, being low and swampy.

The entire township is heavily timbered with large spruce, poplar, balm of gilead, balsam and banksian pine. Much tie timber and some pulpwood have been cut along the Watabeag river. Forest fires in 1921 swept over the northwest quarter, destroying the forest growth.

The Watabeag and Little Driftwood rivers drain respectively the east and west portions of the township. Small creeks tributary to these two streams are numerous. The only lakes seen are in lots 9 and 10, concession VI.

The country along the line between lots 8 and 9, from south to north, is rough. Rocky hills, over one hundred feet above the surrounding country, are numerous. Merriman mountain on the northern boundary immediately west of the Watabeag river is probably the finest point of vantage in the area, being 400 feet high. A splendid view of the surrounding country for miles around may be had; the valley of the Watabeag, winding southward, presents a picturesque setting. Commanding views may also be obtained from Ibsen and Pinero hills. From the summit of the latter hill, a fascinating panorama of wooded plain and gently rolling hills unfolds itself to the east and west, the view south being obstructed by Ibsen hill. The three large hills near the northeast corner of the township are an outstanding feature. The intervening country is a flat woodland with a dense growth of poplar, birch and spruce. Due east, the country appears almost level, broken only by the rocky hills on the eastern boundary of McCann township. To the southwest a rolling succession of round-topped hills and shallow valleys is presented, stretching away as far as the eye can see. A strip of spruce running in a northerly direction marks the course of the Little Driftwood.

The Watabeag river is navigable across the township, but the Little Driftwood, on account of the many log jams, is useless as a canoe route. A good wagon road branches off the main Watabeag Dam road at the forks, near the southern boundary of McCann, and leads to the camps on the banks of the Watabeag river, along the southern boundary and near concession I. A first-class trail leads from the camps on the southern boundary to the Lightning River Gold Mines property in lot 9, concession III. A winter road, which affords a good trail, follows along the Watabeag river to Wasach, on the Temiskaming and Northern Ontario railway, at the crossing of the Watabeag river. On the northern boundary of Egan township, west of Merriman mountain, there is a rock, light to dark greenish-grey in colour. The rock is of porphyritic character, having flesh-coloured phenocrysts of alkali-calcic plagioclase: the rock may be called a porphyrite. The age could not be determined in the field as no contacts were seen. It is tentatively left in the Keewatin, but is probably younger.

Sheraton Township

Time did not permit completing the geological survey of Sheraton. A few sections only were made, which afford some idea of the general aspects of the township, of use to the prospector.

Sheraton township is not very accessible except by canoe in the north, up the Driftwood river from Monteith to Moose lake in Bond township, then south to the lake, along the line between lots 6 and 7, concession VI. Our party entered Sheraton by way of Egan and Timmins townships. These routes are not recommended. In the western third of the township a rolling sand plain area extends from concession I to concession VI. A tract of good agricultural land extends from north to south across the central part of the township. The soil is clay and clay loam.

Near the eastern boundary of the township, the country is rougher, and there are some abrupt rock exposures, particularly in concessions III and IV. The southeast corner of the township is largely Keewatin. There is a contact between the Keewatin and granite near the north boundary of lot 1, concession III. The northeast quarter of the township is underlain with granite. Exposures are most common along the lot 4 and 5 line north from Con. III. According to field notes of W. Galbraith, O.L.S., surveyor in charge of township survey, an abnormally low magnetic declination, varying from 0° to 5° west, was evidenced in the four square miles in the southeast corner of the township.

Michie Township

Michie township is the most rugged in the area, prominent, high rocky hills being found in all parts. The country for a mile east and west of Radisson lake is particularly rough, and rocky hills are of common occurrence. The country lying north of Radisson lake and east of Radisson creek, is sand-covered and appears to have been burnt over about thirty or forty years ago. Small areas of the original jack pine remain.

Along the western boundary the country is level land, heavily timbered with a mixed forest of cedar, birch, balsam, spruce and poplar, of from eight to eighteen inches in diameter. Timber of commercial size is also to be found between Radisson lake and the eastern boundary.

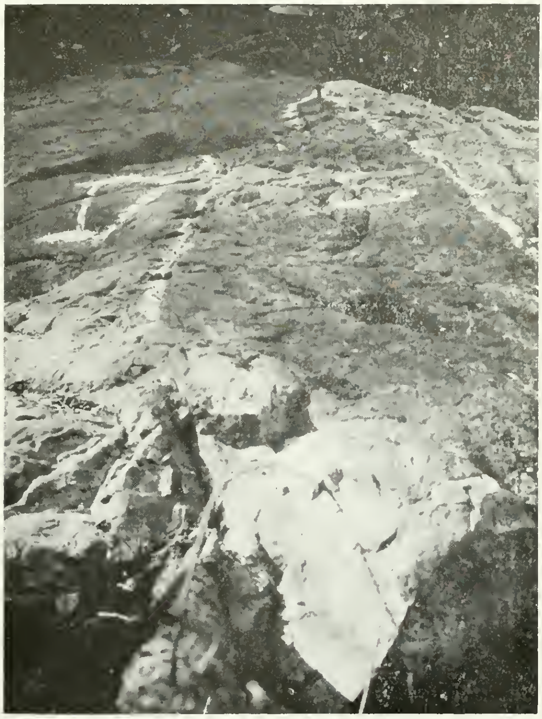
Within the township are several large lakes, Radisson being the largest. The water in Radisson lake is quite clear and in places more than 100 feet in depth. The shore line on the west is all rocky. A precipitous rocky shore, thirty to fifty feet high, extends north from the southern boundary for several hundred yards. It was thought that this shore might possibly represent a fault scarp, with a north to south strike, and that weathering along the fault had produced a valley of which Radisson and the north-to-south string of lakes in Robertson township occupy a part.

The northeast quarter is underlain with Keewatin rocks. Elsewhere the underlying rock formation is largely granite, with the exception of a few patches of Keewatin on the shores of Radisson lake and along the southern boundary of the township. Diabase dikes, usually with a northerly strike, are common, cutting both the Keewatin schists and the Algoman granites.

The canoe route from Stewart to Radisson lake, by way of Macphail lake, is not recommended, as the portages, besides being long, are poorly cut out and lead through considerable swampy country.

Timmins Township

The many lakes in the sand plain country make all sections of Timmins township reasonably accessible. Radisson creek is not navigable by canoes, except for a short distance south from the Nighthawk lake-Radisson creek portage.



A three way contact near the east shore of Saral lake, Timmins township. Fresh diabase, intrusive through Keewatin hornblende schist, and pink weathering hornblende-feldspar porphyry of Algoman? age. The feldspar porphyry is the light colored rock in the upper right hand corner of the picture. Contacts have been accentuated with white chalk.

Radisson creek appears to follow a topographical and geological boundary. All rock outcrops seen west of the creek are granite and those to the east are Keewatin or low knolls of fresh diabase and granite presumably, dike remnants which have resisted erosive influence better than the Keewatin rocks which they intruded. The country lying east of Radisson creek is largely sand-covered, whereas that to the west is low, swampy and covered with spruce. The northern portion of the township is mostly swampy, with minor tracts, ridges and hills of sand. In the vicinity of Island lake the country is more rugged, and several hills rise from one to three hundred feet above the surrounding country. The Saral hills comprise a chain which has a north to south length of three miles, bordering Island and Elspeth lake on the west. The hills consist of hornblende and chlorite schists, liberally intruded by a coarse, fresh diabase together with a few granitic dikes, some of porphyry, of Algoman ? age. The only other rock outcrop of any extent is in the northeast part of the township, where a north-south ridge composed of fresh diabase appears intrusive through the granite at its southern extremity and through the Keewatin at its northern extremity. The dike can be traced for nearly three miles along the strike.

Small, widely separated sections represent the only agricultural lands in the township. They are not of sufficient extent to be of economic importance, even though the township may be more accessible in the future.

Timber resources are average; no large recent brulé areas exist. Jack pine is the principal species represented. Areas of good spruce are situated in the northeast, in the north and in the strip west of Radisson creek. In the more rugged portions there is a very heavy growth of medium-sized timber. Spruce, balsam, birch and poplar are the most abundant species.

INDEX

Vol. XXXI, Part VII.

PAGE

Abitibi Power and Paper Company, Ltd. 2
Abitibi River area 11
Access to area 2, 3
Acknowledgments 2
Actinolite 13
Agricultural land 6, 23, 25, 26
Albite 12, 13
Algoman 11-15
  Fluorite 18
  Granite batholith 12
  Quartz veins 15
Amphibolite 10
Analyses
  Hornblende-albite syenite 13
  Syenite porphyry 12
Andrew lake 23
Ankerite 22, 23
Apatite 13
Assay, gold.
  Biederman claim 21
  Lightning River Gold Mines 21
Azurite 18

Balm of gilead 26
Balsam 5, 26, 28
Bear 5
Beaver 5
Beatty township gold area 1
Biederman gold claim.
  Assays 21
  Diamond-drilling 21
  Notes 21
  Ref. 19
Biederman, William 21
Biotite 11, 13, 21
Birch 6, 11, 24, 27, 28
Black river.
  Drainage area 4
  Refs. 1, 2, 11
  Waterfalls 4, 5
Black tp.
  Cobalt series 15
  Refs. ....1 and *n*.
Blackwater lake 2
Blackwater-Lockpot lake route 2
Boundaries of area 1
Brulé 5, 30
Brunnerite 22
Burrows, A. G. 10, 13, 16

Cairo tp.
  Fluorite 18
  Refs. 12, 15
Calcite 13, 22
Canoe routes 2, 6, 24, 25, 26 27
Carbonate 11

PAGE

Cariad lake 3
Caribou lake 6, 23
Cautts creek 4
Cautts lake 4
Cedar 27
Chalcopyrite 18, 19, 21
Chlorite 10, 11, 13
Clay Belt post office 24
Cobalt bloom 19
Cobalt series 3, 7, 15, 24, 25
Cocklin, T. E. 24
Cook tp. 7
Cooke, H. C. 12*n*, 16
Copper 19
Copper-bearing minerals 19

Davis lake 2
De Courcey lake 23
De la Vérendrye 3*n*
Diabase 7
Diabase hill 16
Diamond drilling
  Biederman gold claims 21
Dolerite.
  Explanation of term 10
Dome mill, Tisdale tp. 10
Dougherty, J. W. 2
Drainage areas 4
Driftwood river 4
Dunmore tp. 12, 21

Economic geology 18-23
Egan chutes, McEvay tp. 5
Egan tp.
  Agricultural land 6, 25
  Albite-syenite porphyry 12
  Chalcopyrite 18
  Forest fires 5
  Gold 18, 22
  Granitic dike intrusion 12
  Magnetite 18
  Notes 25, 26
  Timber 26
Elspeth lake 28
Epidote 11
Erythrite. *See* Cobalt bloom.
Extent of Watabeag area 1

Fall Duck lake 19
Feldspar 11, 12, 13, 20
Felsite 20, 23
Fish 5, 6
Forest fires 5, 24, 27, 28
Fort Matachewan 1
Fur-bearing animals 5

Page
Galbraith, W., O.L.S. 28
Game 6
Geological outline 6-18
Geological formations (table) 7
Goodwin, W. M. 2
Gold 19-23
Gossan 21
Gould 19
Granite 7
Greenstone 9
Greenwood, W. 2
Grey lavas 11

Height of land 1
Holmes tp. 12
Hornblende-albite syenite 12
Hornblende schist 10
Hutchison, F. L. 2

Ibsen hill 27
Iron 18
Iron pyrites 21
Island lake 17, 28

Jack (banksian) pine 5, 6, 23, 24, 26, 28
Joliet (explorer) 3*n*

Kaolin 11
Kay, George F. 1, 2
Keewatin 7-11
Keewatin schist 10
Kempis mountain 22
Kirkland Lake gold area 1
Knight, C. W. 1, 19*n*

La Salle (explorer) 3*n*
Labradorite 7
Lake trout 5, 6
Lakes 4, 25

  Flows 7, 8
  Pillow, Playfair and McCann tps. 8
    Playfair tp. (photo) 10
Lee tp.
  Cobalt series 3, 15
  Greywacké (photo) 16
  Notes 24
  Timber 5, 24
Legris,—? 19
Lemoine lake (photo) 25
Lightning River Gold Mines, Ltd.
  Assay 22
  Notes 21, 22
Link lake 6
Little Driftwood river 26
Lockpot lake 2, 26
Long Watabeag lake 6

Macgillivray, J. C. 2
Mackay creek 4
Mackay lake 4
Macphail lake 29
Magnetite 18
Main Watabeag lake 6, 12
Maisonville tp. 21
Mapping of area 1, 2
Marl 5

Page
Marquette (explorer) 3*n*
Matachewan 1
Matachewan area.
  Barite veins 18
  Cobalt series slate and quartzite 18
Matheson 2
Matheson fire in 1916 5, 23
Matheson-Watabeag Dam road 23
McCann tp.
  Agricultural land 6, 24
  Cobalt series 15
  Contact shatter-breccia (photo) 14
  Dikes, aplite and feldspar porphyry 17
  Forest fires 5
  Granitic dike intrusion 12
  Hornblende-syenite porphyry outcrops 12
  Keewatin-granite batholith contact 15
  Lava flows 7
  Notes 24
  Pillow lava 8
  Pleistocene 18
  Timber 24
McDougall, Wasil 1
McEvay tp.
  Notes 26
  Pleistocene 18
  Timber 26
  Waterpowers 5
McNeill, W. K. 12
Mercer,—? 19
Merriman mountain 27
Michie tp.
  Notes 28, 29
  Post-Algoman diabase 17
  Schistose granite dike 15
  Timber 27
Microcline 12, 13
Miller, W. G. 15, 19*n*
Mobb, Fredrick 19, 20
Mobb gold claim.
  Notes 20
  Rocks 14
Molybdenite 19, 20, 23
Monteith 26
Moose 5
Moose lake, Bond tp. 26
Moose river 4
Munro gold area 1
Munro tp. 10

New York 21
Nighthawk lake 2
Nighthawk drainage basin 4
Nordica tp.
  Area in Watabeag basin 6
  Forest fires 5
  Notes 26, 27
  Pleistocene 18
  Post-Algoman diabase 15
  Schist 10

Ontario Land Survey party (1905) 19

Phanerite 20
Pike 5
Pinero hill 27

Page

Plagioclase 12
Pickerel 5
Playfair tp.
  Acid volcanoes 11
  Agricultural land 6, 23
  Gold 18, 19
  Lava flows 7
  Matheson fire 5
  Notes 23, 24
  Pillow lava 8 10
  Pseudo-conglomerate (photos) 8, 9
  Waterfall on Black river 4
  Waterpowers 5
Pleistocene 2, 3, 6, 18, 24, 25
Poplar 5, 6, 24, 26, 27, 28
Porcupine gold area 1
Post-Algoman diabase 15-17
Potter Lumber Company, R. S. 2
Pulpwood 25

Quartz 11
Quartz-albite syenite 12

Radisson (explorer) 3*n*
Radisson lake
  Acid volcanoes 11
  Fluorite 15
  Foliated Keewatin schists (photo) 9
  Refs. 4, 18, 27
Radisson (Trout) creek, Timmins tp. 2, 27
Radisson-Currie lake portage 19
Ramore 7, 24
Red deer 5
Rhyolites 11
Roads 2, 6, 21, 24
Robertson tp. 12

Sanborn lake 15, 27
Sand. *See* Pleistocene.
Sanlupe 13
Saral hills 28
Saral lake, three-way contact (photo) 28
Sarsfield lake 24
Schists, Keewatin 8, 9
Sericite 11
Serpentine 11
Sesekinika lake 21, 25
Sheba tp.
  Area in Watabeag basin 6
  Ref. 12
Sheraton tp. 4
  Agricultural land 6, 28
  Notes 28
Soils. *See* Agricultural land.
Sphene 13
Spruce 5, 25, 27, 28, 30
Stewart lake 4
Syenite 7, 18

Tabicoe,—? 19
Temiskaming and Northern Ontario Railway 2, 23, 26

Page

Terry tp.
  Area in Watabeag basin 6
  Biederman claims 21
  Gold 18
  Molybdenite 19
  Notes 25
  Pleistocene 18
  Refs. 1, 4, 19
Thomas tp. 4
Timmins tp.
  Agricultural land 30
  Gold 18, 19, 21, 22
  Molybdenite 19
  Notes 29, 30
  Timber 30
Timber 5, 6, 25, 28
Tisdale tp., rocks 10
Titanite 13
Titanium 18
Tolstoi creek 25
Tolstoi tp.
  Agricultural land 25
  Area in Watabeag basin 6
  Cobalt series 15
  Notes 25
  Pleistocene 18
  Timber 5
Toy-Sanborn lake portage 16
Tomwool creek 3
Trout 3*n*, 5, 6
Turkey lake 24

Walkerville, Butte, Montana 13
Wasach 28
Waterpowers 5
Watabeag, translation of 1
Watabeag area, topography 2, 3
Watabeag basin.
  Lakes included in 6
  Table of acreages in 6
  Townships comprised in 1
Watabeag Dam road 2, 26
Watabeag lake.
  Depths in 6
  Fish 5, 6
Watabeag river.
  Refs. 2, 4, 5, 17, 27, 28
  Waterpowers 5
Water in area, characteristics of 3
White Clay river 4
White pine 5, 6
Whitefish 5
Whitefish river 4
Wild animals 5
Wildgoose lake 17, 24
Wildgoose river.
  Refs. 4, 5
  Waterpowers 5
Wildgoose siding, *See* Ramore.
Wolverton lake, Timmins tp. 23

Zircon 12

PROVINCE OF ONTARIO
DEPARTMENT OF MINES

HON. H. MILLS, MINISTER OF MINES
THOS. W. GIBSON, DEPUTY MINISTER

THIRTY-FIRST ANNUAL REPORT
OF THE
ONTARIO DEPARTMENT OF MINES
BEING
VOL. XXXI, PART VIII, 1922

CONTENTS OF PART VIII

PAGES
Iron Formation of Lake St. Joseph by E. L. Bruce - 1-32
Eastern Part of Lake St. Joseph by E. L. Bruce - - 33-38
Area South of the West End of Lake St. Joseph by E. L. Bruce - - - - - - - 39-40

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY OF ONTARIO

TORONTO
Printed by CLARKSON W. JAMES, Printer to the King's Most Excellent Majesty
1923

Printed by
THE RYERSON PRESS

CONTENTS

Vol. XXXI, Part VIII

Page

IRON FORMATION OF LAKE ST. JOSEPH

Introductory ... 1
Field Work ... 1
Acknowledgments ... 1
Position, Area and Means of Access ... 1
Previous Work ... 2
Summary ... 2
Topography ... 3
  Local Topographic Divisions ... 3
Drainage ... 6
Waterpowers ... 6
Pulpwood and Timber ... 6
Agriculture ... 6
Fish ... 6
General Geology ... 7
Pre-Granite Complex ... 7
Sedimentary Division of Pre-Granite Complex ... 7
  Description of Rock Types ... 7
The Iron-Bearing Beds ... 10
  General Character ... 10
  Distribution ... 11
  Origin of Sedimentary Beds ... 11
  Metamorphism of the Sediments ... 12
  Succession of the Sediments ... 12
  Similar Rocks in Adjacent Areas ... 13
Igneous Division of the Pre-Granite Rocks ... 13
  General ... 13
  Acidic Flows ... 13
  Alteration ... 15
  Distribution ... 15
  Origin ... 16
  Comparison with Rocks in Adjacent Areas ... 16
  Basic Volcanic Rocks and Associated Schists ... 16
  Age Relations of the Igneous Pre-Granite Rocks ... 19
Rocks of the Granite Intrusions ... 19
  Rock Types ... 19
  Age Relation of the Granite ... 21
  Glacial Formations ... 21
  Recent ... 21
  Geological History ... 22
Economic Geology ... 23
  History of Prospecting ... 23
Iron Formation ... 24
  Character of the Iron Occurrences ... 24
  Mineralogy of the Iron Formation ... 24
  Associated and Interbedded Rocks ... 25
  Origin of the Iron-Bearing Beds ... 26
  Hypothesis of Contact Metamorphism ... 26
  Hypothesis of Clastic Sedimentation ... 26
  Hypothesis of Chemical Precipitation ... 27
  Comparison with Lake Savant Occurrences ... 29
  Composition of the Deposits ... 30
  Depth of the Deposits ... 31
  Possibility of Enriched Lenses ... 31
  Possibility of Concealed Lenses of Magnetite ... 32
Quartz Veins ... 32

EASTERN PART OF LAKE ST. JOSEPH.

Introduction ... 33
Summary ... 33
Timber ... 33
Geology ... 33
Pre-Granite Complex ... 34
  General ... 34
  Sedimentary Group ... 34
  Igneous Group ... 36
  Granite and Other Intrusives ... 36
Recent ... 37
Pleistocene Deposits ... 31

AREA SOUTH OF THE WEST END OF LAKE ST. JOSEPH.

Introduction ... 39
Geology ... 39

ILLUSTRATIONS

Iron Formation of Lake St. Joseph.

Fig. 1.—Marshy longitudinal valley occupied in part by a bay of Lake St. Joseph 3
Fig. 2.—Hummocky ridges of glacial sands and gravels lying between Lake St. Joseph and Lake No. 1. 4
Fig. 3.—Terminal moraine lakes, north of the narrows of Lake St. Joseph, viewed from a height of 2,700 feet 5
Fig. 4.—Ropy-looking rock of the sedimentary group 8
Fig. 5.—Band of conglomeratic material containing nodules of magnetite 10
Fig. 6.—Photomicrograph of section of quartz porphyry from Island 400, showing absorbed phenocrysts of quartz 14
Fig. 7.—Photomicrograph of quartz porphyry from Island 400, showing feldspar phenocrysts 14
Fig. 8.—Pyroclastic rock on the north side of the narrows, Lake St. Joseph. . 18
Fig. 9.—Photomicrograph of quartz porphyry fragments in pyroclastic rock, north side of the narrows, Lake St. Joseph 18
Fig. 10.—Glacial boulder of granite on the shore of Blackstone lake 20
Fig. 11.—Part of Lake St. Joseph from an altitude of 2,500 feet, looking southwest 23
Fig. 12.—Outcrop of iron formation on Island 84, showing the platey structure formed by weathering in schistose rock 24

Eastern Part of Lake St. Joseph.

Fig. 1.—Photomicrograph × 30 of quartzite from the south side of the bay crossed by the base line between Mile XII and Mile XIV, Eastern part of Lake St. Joseph 35
Fig. 2.—Lake in terminal moraine deposits, south of Lake St. Joseph 36
Fig. 3.—Osnaburgh House, Lake St. Joseph, viewed from an elevation of 800 feet 37
Fig. 4.—Island 670, Lake St. Joseph, showing sand spit formed on the south side 38

GEOLOGICAL MAPS

(In pocket inside back cover).

No. 31e.—Western Part of Lake St. Joseph, scale one mile to the inch.
No. 31f.—Eastern Part of Lake St. Joseph, scale two miles to the inch.

IRON FORMATION OF LAKE ST. JOSEPH

By E. L. Bruce

Introductory

It has been known for some years that iron formation occurs at Lake St. Joseph on the Albany river, but as no thorough examination of the deposits for public information had ever been made, and as the region is now fairly easy of access, the writer was instructed by the Ontario Department of Mines to examine the ore deposits and the associated rocks of that region during the field season of 1921.

Field Work

The field work covered a period from the first of June to the middle of September. The shores and islands of the western part of Lake St. Joseph were examined in detail during the first part of the season, and inland traverses were made by pace and compass methods at closely spaced intervals. Along the south shore, owing to magnetic disturbances, it was necessary to use the dial compass; dip needle observations were also made. Small lakes inland from the main lake were located and surveyed by stadia and compass, and the southern part of Blackstone lake, which is included in the map sheet, was also surveyed. Special attention was given to the delineation of the iron-bearing beds. Their possible extension and connections under the lake were determined by dip-needle readings taken by canoe on calm days. In this way it was possible to obtain assurance of the continuity of certain beds. Average samples over considerable widths were taken at some of the more promising occurrences. Some quartz veins were also sampled.

Acknowledgments

Thanks are due to L. G. Williams of the Hudson's Bay Company at Sioux Lookout, to G. B. Murray of Hudson, and to David Wright, in charge of the post at Osnaburgh House, for assistance and hospitality during the field season. J. W. Greig, J. F. Comer, G. L. Fraser, and L. F. Williams, were capable assistants. A large part of the stadia survey made is the work of Mr. Greig, and both Mr. Greig and Mr. Comer assisted efficiently in the geological work. Through the courtesy of Captain A. W. Carter, in charge of the Air Board Station at Sioux Lookout, it was possible to arrange at the close of the field season a flight over the area mapped.

Position, Area, and Means of Access

Lake St. Joseph, practically at the head waters of the Albany river, is on the boundary between the districts of Kenora and Thunder Bay on the south and Patricia on the north. The western end is sixty miles north of the Canadian Government railway at Superior Junction. The area dealt with in this report comprises four townships, three lying west, and one east of the meridian run by J. S. Dobie, O. L. S. in 1919. The southwest corner of the eastern township is at Mile LX on this line.

The area is reached most easily from the Government railways either at Sioux Lookout or at Hudson. From either place the route follows the river to Lac Seul. From Hudson the only obstruction is at Manitou rapids, but the powerful motor-boats used by the Lac Seul fishermen are able to go up or down, except during the spring freshet. From Sioux Lookout there is a thirty-chain portage at Pelican falls before reaching Manitou rapids. The route crosses the eastern end of Lac Seul to the mouth of Root river; thence up that river, which is obstructed by a number of rapids, requiring ten portages. The portage across the height of land which separates Root river from a sluggish stream draining into Lake St. Joseph, is half a mile in length, and much of it is muskeg, across which a pole walk has been made. The route is not a difficult one, as motor-boats can be used as far as the mouth of Root river.

Previous Work

Although Lake St. Joseph has been a main trade route of the Hudson's Bay Company from early times, little mention of it is made in the accounts of early explorers. The first geological literature dealing with the region is the report of Dr. Robert Bell.[1] A transit and micrometer survey had at that time been made by Thomas Fawcett, D.T.S., and this survey is the basis of all the maps up to the present.

In 1900 John E. Davison was attached as geologist to survey party No. 9, and the result of his observation, together with reports by the surveyor in charge, was published by the Ontario government.[2] In 1902 A. W. G. Wilson of the Geological Survey of Canada made an exploration of neighbouring districts, and in his report certain references are made to Lake St. Joseph.[3]

In 1904 William McInnes and Charles Camsell, of the Geological Survey of Canada, crossed parts of Lake St. Joseph on their way to Attawapiskat river and Cat Lake districts respectively, but the country in the vicinity of Lake St. Joseph was not examined by them. In 1919 James S. Dobie, O.L.S., completed a meridian line northwards to Lake St. Joseph, and in 1920 he surveyed the part of the lake west of the meridian and outlined a tier of three townships. A. L. Parsons accompanied the party in 1919 in the capacity of geologist.

Summary

The Lake St. Joseph area is typically pre-Cambrian in character. The topography consists of an irregular hummocky section of small relief developed upon granite, a section of linear ridges upon foliated rocks, and an irregular hummocky section of terminal moraines. The rocks consist of a group of sedimentary origin, with which iron-bearing beds occur, overlaid without any erosion interval by quartz porphyry and andesite flows. These rocks are cut by lamprophyric dikes, granite batholiths and pegmatite dikes. All are of pre-Cambrian age. They are covered in part by glacial and recent deposits.

---

[1] Geol. Sur. Can. Vol. II, Part G. 1886.

[2] Report of the Survey and Exploration of Northern Ontario, 1900, (1901) pp. 230-249.

[3] Report of a Traverse Through the Southern Part of the North-West Territory from Lac Seul to Cat Lake in 1902. Geol. Surv. Publication 1006.

The formations of economic interest are the iron-bearing beds. Channel samples of the most promising lenses do not show a sufficiently high iron content to make them workable without concentration. Concentration tests have not proved encouraging, owing to difficulties encountered due to the fine-grained texture, and to the intimate mixture of hematite and magnetite. Quartz veins occur, but none were found carrying any values in gold. The rock association, however, seems favourable for the occurrence of gold quartz deposits.

At present, fur is the only product of the region. Fish, however, are plentiful and of good quality. Some areas of good pulpwood still remain, but much of the country in the vicinity of the lake has been stripped of timber by forest fires. There are no available waterpowers, but should more water storage be necessary for the Winnipeg river power development, it seems possible that the drainage of the Lake St. Joseph basin could be diverted into Lac Seul.

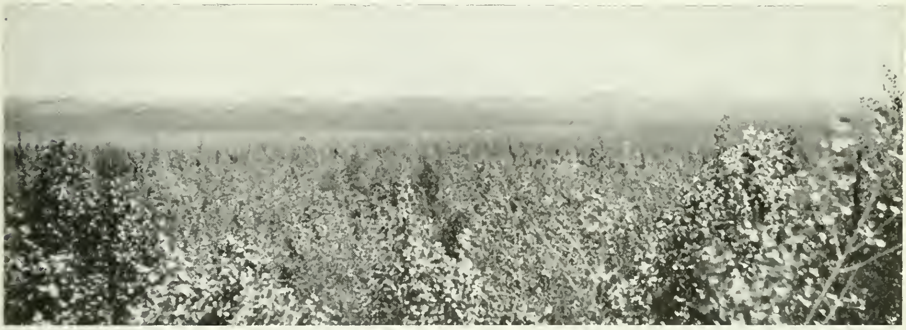


Fig. 1.—Marshy longitudinal valley occupied in part by a bay of Lake St. Joseph. The top of the ridge to the south is glacial sand.

Topography

The area in which Lake St. Joseph lies is part of the pre-Cambrian shield, and its topography is similar in all respects to the general topography of other parts of that region. The surface features of this great geological element have been described so often that it is not necessary to recapitulate those characteristics which are common to all parts of the shield. There are certain local modifications that will be described briefly.

Local Topographic Divisions

In the four townships covered by this report three local topographic divisions are recognizable:

1. The part lying south of the lake in the two western townships.
2. The northwestern part of the two western townships.
3. The two eastern townships.

These divisions do not include the islands. The larger ones, however, belong to the first division.

The Southwest Division.—The southwestern topographic section consists of east-west trending ridges separated by fairly continuous valleys, Fig. 1. Parts of many of the valleys are occupied by narrow bays of Lake St. Joseph, connected to the main lake usually by narrow channels. Other parts of these longitudinal valleys are marshy or swampy, with sluggish streams draining into the heads of the bays. The elevation of the ridges is 100 to 150 feet above lake level.

The linear topography is directly related to the underlying rock structure. The general east-west strike of the almost vertical beds of gneiss, greywacké and quartzite lends itself to the development of straight valleys, either along the softer beds or along lines of structural weakness developed during the folding. Ridges in many cases are formed by massive beds of gneiss or quartzite. The lenses of magnetite are resistant and stand up prominently above the other rocks. A notable example of this is the horseshoe-shaped ridge that forms the lake shore of the southeastern part of Island 84. The marked variation from the usual east-west trend of the ridges is due to the sharp buckling back of the magnetite bed. Inside the flanking ridge a swampy valley parallels the hard layer.

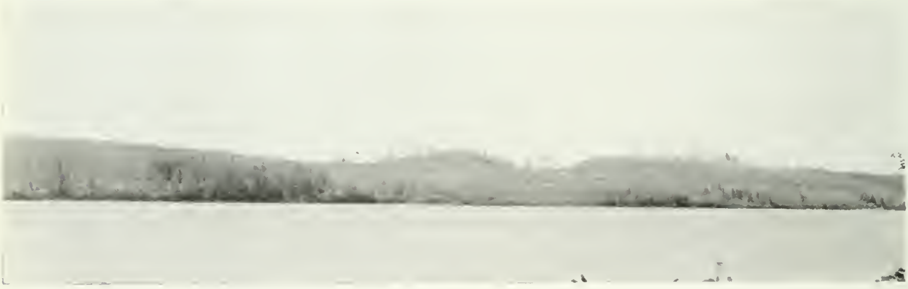


Fig. 2.—Hummocky ridges of glacial sands and gravels lying between Lake St. Joseph and Lake No. 1.

Pegmatite dikes, which are numerous south of the lake, form isolated elevations. As the dikes are not necessarily parallel to the bedding, ridges developed by them do not in all cases conform to the general east-west trend.

The Northwest Division.—Northwest of the long narrow bay north of the main channel of the lake, there is an area of rounded hummocky topography with lakes of irregular outline. The underlying rock is massive granite. The difference of relief is small, since there are no marked differences in rock hardness in the various parts. Although most of the lakes have irregular shore lines and the bays extend in all directions, there are some that have exceptionally long, straight, narrow bays. An especially striking example is the bay of Lake St. Joseph, referred to above. Immediately to the north of it, however, a part of Blackstone lake is joined to the main lake by an equally narrow and straight channel trending at an angle of about sixty degrees to the long arm of Lake St. Joseph. These directions are probably determined by the jointing system of the granite.

The Eastern Division.—The solid rock of much of the inland section of the two eastern townships is concealed beneath glacial deposits. Solid rock is found to elevations of approximately 100 feet above lake level; above that the glacial drift over-burden forms hills as high as 150 feet above the lake. The topography is typical of terminal moraines. There are the characteristic hummocky hills, Fig. 2, among which lie oval lakes, many without visible outlets, Fig. 3. In some places the ridges have a rough southwesterly trend following the direction of motion of the Patrician glacier. Along the lake shore sand beaches extend for long distances. Behind the beaches, banks of sand rise abruptly, in places actually forming cliffs. Material eroded from the sand ridges is carried along the shore by lake currents, and in favourable positions is deposited as sand spits or bay bars. Rather remarkable sand bars have formed across the shore ends of some of the bays, Fig. 3, and behind them marsh vegetation has filled up the shallow water to form great meadows. Some of these marshes drain out through the sand; others have sluggish streams flowing out through breaches in the bar. In some places parts of the lake are separated only by such barriers. The neck of land joining the main part of the peninsula along the meridian line, north of the narrows, consists only of a marsh bordered on each side by sand beaches. It will be noticed from the map that the second pair of bays north of the narrows are actually connected by a water-way, which is passable for canoes even during comparatively low water.

Photograph by courtesy of the Air Board of Canada

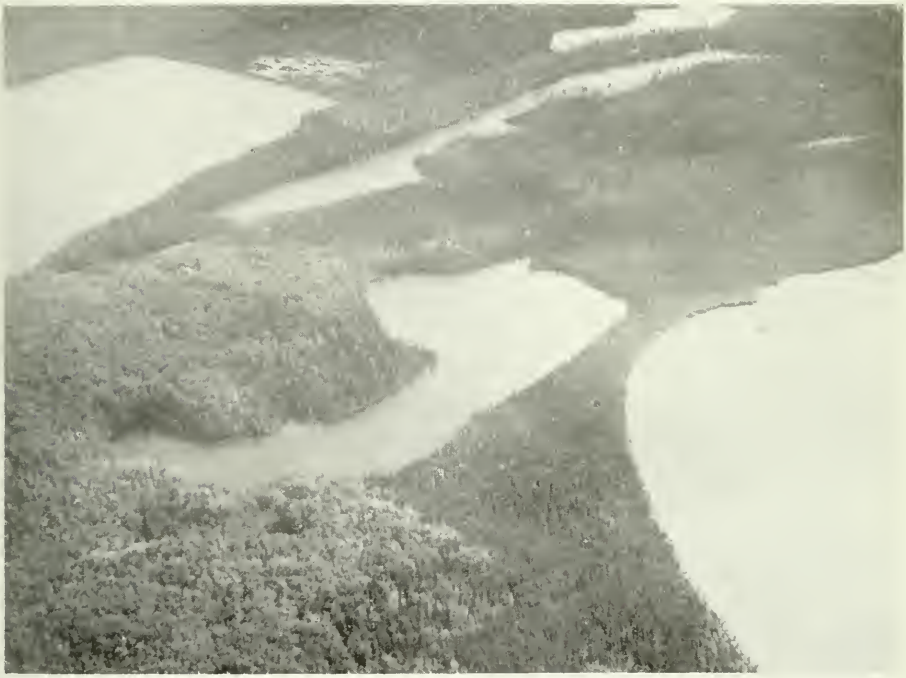


Fig. 3.—Terminal moraine lakes crossed by the meridian north of the narrows of Lake St. Joseph, viewed from a height of 2,700 feet.

Drainage

Lake St. Joseph is the collecting basin for the several small streams which form the head waters of the Albany river. Blackstone lake, which gathers the drainage from a large area to the north, empties into Lake St. Joseph by two mouths. At the west end of Lake St. Joseph a sluggish stream, separated from Root river and the Lac Seul drainage system only by a half mile of low country, flows into the lake. Along the southern shore, the only incoming stream of any volume enters the long southerly-extending bay east of the meridian. This stream receives part of its water from Shekak lake and other lakes lying south of lake St. Joseph and west of the meridian line, and part from a series of lakes east of that line.

Waterpowers

No waterpower can be developed on any of these streams. The fall between Blackstone lake and lake St. Joseph is only two feet, and the volume of water is not large. The other streams are still smaller. Root river has several rapids, but there is not sufficient fall at any one place nor sufficient water to produce a commercial waterpower.

There is a possibility that Lake St. Joseph waters could be diverted to the Root river and Lac Seul basin to increase the water supply for power purposes below Lac Seul. Levels taken across Root portage show that lake St. Joseph is 3.4 feet higher than Root river at the southern side of the portage. The greatest elevation on the portage is less than 25 feet above Lake St. Joseph. So far as can be judged from the surface much of this 25 feet is clay and sand. In any case it would not be a great undertaking to cut through the divide and turn all the lake St. Joseph waters southward to Lac Seul.

Pulpwood and Timber

Fires have destroyed most of the forest growth near the lake in the four townships dealt with in this report. Only one area of fair-sized spruce remains unburned. This lies north of the lake just west of the meridian line. It consists chiefly of spruce, four to eight inches in diameter. A few other small patches of spruce remain in some of the swampy sections. Owing to the sandy glacial deposits much of the original growth was jack pine.

Agriculture

The climate is not too severe for most vegetables and hardy grains. Gardens are cultivated at the Hudson's Bay Company post, on the north shore of Lake St. Joseph, known as Osnaburgh House,[1] but the sandy soil makes it impossible to raise good crops except in wet seasons.

Fish

Lake St. Joseph is well stocked with fish of good quality. The food varieties found are whitefish, pickerel, and pike.

---

[1] *See* illustration, page 37.

General Geology

The rock formations of the area are all of pre-Cambrian age. They consist of sediments and lava flows intruded by granite batholiths. Structurally, they form a syncline of which the northern limb has been entirely destroyed by the igneous intrusions.

The age relations of the various types are shown in the following table.

TABLE OF FORMATIONS

Age	Relations	Rock Type
RECENT		Peat Sand, Clay, Gravel
GLACIAL	*Unconformity*	Pegmatite dikes
PRE-CAMBRIAN		Granite Lamprophyre dikes
	Intrusive Contact	
	Pre-Granite Complex	*Volcanic Group*— Greenstone, Diorite, Chlorite schist, Pyroclastics, Quartz porphyry, Sericite schist. *Sedimentary Group*— Iron-bearing beds, greywacké, quartzite, arkose, biotite gneiss, biotite-garnet gneiss, quartz-hornblende gneiss, sericite and chlorite schists.

Pre=Granite Complex

The pre-Granite Complex consists of two unlike parts, one chiefly sedimentary, the other chiefly igneous. The sediments are highly metamorphosed clastic rocks of the following types—biotite gneiss, biotite-garnet gneiss, hornblende gneiss, arkose, greywacké, quartzite, chlorite and sericite schists, carbonate rocks, magnetite-hematite beds, and magnetite-hematite-jasper beds. There are many gradations between all these, and no one type can be traced for any great distance.

Sedimentary Division of Pre=Granite Complex

Description of Rock Types

The Gneisses.—Although there can hardly be said to be any definite order of rock types, there is in a general way a band of paragneisses—biotite gneiss, and biotite-garnet gneiss—along the southern side of the map sheet, but other rock types are interbanded. The paragneiss is a greyish to brownish weathering rock, containing biotite which marks the foliation. It is distinctly stratified with different layers marked both by differences in colour and in texture. Ordinarily the bandings are less than one-half inch in thickness, but there are some beds as much as five inches thick. Some of the gneisses consist only of quartz and biotite, others have a considerable amount of pink garnet lying in strings along the foliation or bedding. At Station 207, which is south of Island 353, a well banded gneiss has beds up to eight inches in thickness; the colours are grey and brown. Biotite and quartz can be recognized in the hand specimens. Under the microscope the rock appears fairly coarse with quite fresh, interlocking, quartz grains, biotite and sericite. The platy minerals are not arranged in parallel position, and the banding is probably an original characteristic.

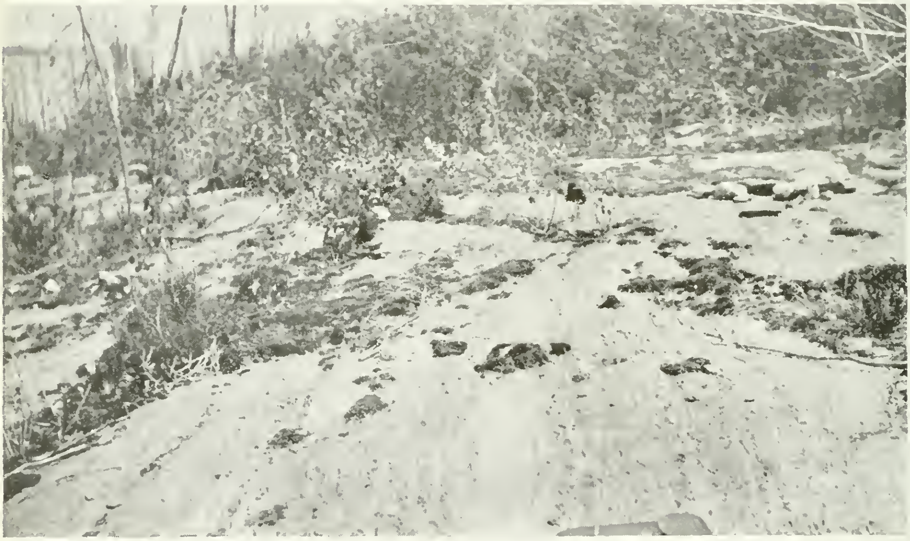


Fig. 4.—Ropy-looking rock of the sedimentary group.

North of the typical paragneiss, but forming a gradational series with it, is a rather remarkable banded rock, with some beds from one inch to three inches in thickness that are similar in all respects to the gneiss. Interlaminated darker bands, however, are made up of chloritic material, and contain gash veins of quartz that begin nearly parallel to the bedding on the north side of the vertical beds, curve across the bed, and in a reverse curve parallel the south side of the bed. They give the rock a peculiar ropy appearance, Fig. 4. Apparently they are the result of the slipping of highly resistant beds over less resistant beds during the folding, with the result that softer, possibly clayey beds between, suffered incipient drag folding. On the eastern point of Island 337 the rocks are very distinctly banded in light and dark grey and brown bands one-eighth of an inch or less in thickness. With these are interlayered crumpled greenish rocks with some quartz stringers. South of Station 136 similar rocks occur. They consist of evenly banded but somewhat granular beds of light brownish grey, interlaminated with schistose, greenish, chlorite rock in which many small gash veins of quartz occur. Some gash veins also occur in the massive layers. One massive bed has a thickness of two and a half feet with many alternations of colour banding. A sample from it under the microscope shows a fine-grained rock with subangular quartz fragments in a matrix made up mostly of iron-stained quartz. It is a somewhat impure quartzite. A sample seven chains inland from Station 13 on the south shore, south of Island 84, comes from an exposure of ropy-looking, rusty rock with quartz gash veins. The thin section shows fresh quartz veins cutting through an iron-stained quartzite.

Quartz hornblende gneiss occurs in the series of sediments on the big point south of Island 407. The greater part of the rocks consists of quartzose or arkosic sediments, but half a mile north of the west end of the narrow bay at the south side of this point there is a band of strongly foliated rock which microscopic examination shows to consist of alternate layers of green hornblende and mosaics of quartz. It is apparently a sediment in which some more richly iron-bearing layers have recrystallized into hornblende.

Greywacké.—The greywackés differ from the gneisses in lack of foliation in the individual beds and the absence of mica or garnet. The rocks are grey and granular. Under the microscope they are seen to be made up of angular to sub-angular and rounded fragments of quartz, orthoclase, plagioclase, and a considerable amount of darker minerals now almost completely altered. A specimen from the sedimentary group on Island 362 is of granular texture not definitely foliated, and contains considerable quantities of dark coloured minerals. The microscope shows the constituents to be sub-angular fragments of quartz, orthoclase, and plagioclase set in a fine-grained matrix.

Arkose.—Many beds of the sedimentary series have a greyish granular appearance. In some outcrops quartz and feldspar are both recognizable in the hand specimen. Under the microscope a sample of rusty-weathering schistose rock from Island 185 shows rounded quartz fragments with altered orthoclase and plagioclase in a finer-grained matrix chiefly of quartz, calcite, and sericite. The rock ten chains east of Station 146 is a finely banded fragmental, with some massive and very hard beds. The sample from these contains rounded quartz fragments with some plagioclase, biotite, and calcite. Many of the rocks associated directly with the iron formation have the composition of arkose; they will be described in dealing with the origin and character of the iron-bearing beds.

Quartzite.—The composition of most of the sedimentary group is largely quartzose. Quartzite and impure quartzite make up much of the rock, and most of the sedimentary gneisses are essentially quartzites in which there is more or less distinct foliation.

Chlorite and Sericite Schists.—In some places the sedimentary rocks have undergone so much deformation that they have been sheared and altered into chlorite or sericite schists. The rocks with considerable quantities of basic minerals have altered into chloritic schists, and the impure quartzites and arkoses have altered into sericite schists. Sericite schists are also formed by the alteration of the quartz porphyry, and basic rocks produce chlorite schists as previously noted. Hence in some localities it is difficult to determine whether the rock was originally a member of the sedimentary group or of the volcanic group.

The Iron-Bearing Beds

General Character

Beds containing large proportions of iron oxide occur near the upper part of the sedimentary group. The iron minerals are magnetite and hematite, in some places interbedded with jaspery material, but ordinarily, with material similar to the fragmental quartzose sediments. The laminated material differs from the usual type of clastic rock in that the greywacké or arkose interbedded with the magnetite or hematite bands contains a considerable amount of carbonate. In some samples the percentage is so large that the rock might with propriety be called a siliceous iron carbonate. So far as seen these carbonate-containing rocks do not occur except in direct association with the iron beds. In many places magnetite or hematite bands occur intimately associated with layers of light pink garnet.

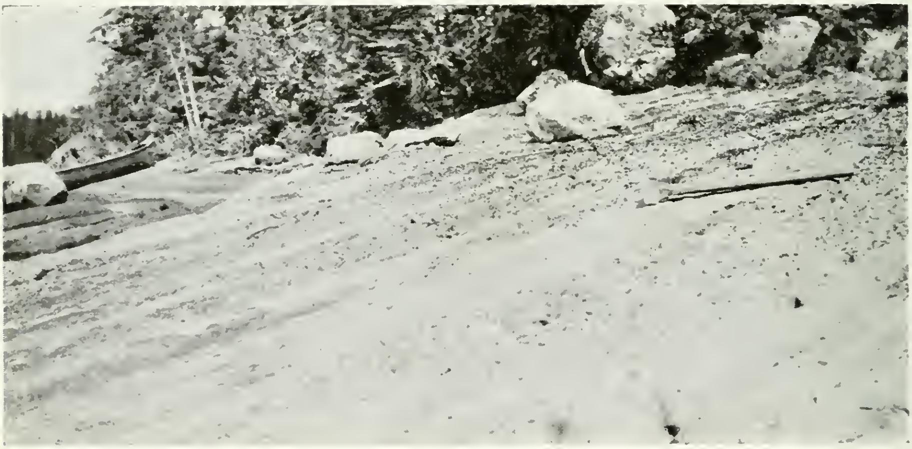


Fig. 5.—Band of conglomeratic material containing nodules of magnetite.

Besides the main bands of solid iron oxides there are certain apparently fragmental rocks of a rather peculiar character. On the weathered surface these appear to be ordinary clastic beds with oval fragments of greywacké, jasper, quartz and magnetite, in a fine-grained ground mass, Fig. 5. The magnetite inclusions are in some cases half an inch in length by two-thirds of an inch in width. The peculiar feature is that the fragments are not nearly equidimensional ellipsoids, but are very much elongated in the vertical dimension, that is, parallel to the original bedding planes. The fragments are thus elongated, cigar-shaped forms.

Distribution

Iron-bearing beds are not confined to any one horizon of the sedimentary series. The thickest and most continuous occur near the northern margin, which for reasons to be given later, is considered to be the upper part of the sediments. There are, however, numerous bands of iron oxides interlayered with sediments far below this main iron-bearing zone, but all these lower bands are thin. All the occurrences are lenticular, and thick lenses may divide into many thinner ones and gradually feather out into normal quartzose sediments.

All the beds stand at high angles, and so the distribution is linear with the exposed width practically that of the thickness of the bed. A very pronounced bed appears on the south shore of Island 84 and forms a well-marked topographic ridge which curves around the southeast part of the island and follows the south shore of the large bay on the east side of the island to its western end, thence northeastward along the northern part of the island and finally bending westward extends southwestward under the lake. Where it next appears it is not one definite bed but several fairly large ones, some of which gradually finger out. Part of this bed, or another lens at about the same horizon, extends along the north side of Island 184 and then westward after buckling sharply northward until it gradually fades out.

Origin of Sedimentary Beds

All the rocks up to and including the iron-bearing beds have been formed under somewhat similar conditions. They are all sedimentary. The bedded character of the biotite gneiss is clearly shown by variations in colour and texture. The beds are of different thicknesses, and of varying mineral make-up. Lines of garnet of the light pink variety, commonly found in sediments, mark the original bedding planes. Staurolite occurs with a similar series farther east, and assuming the identity of the two the presence of staurolite is conclusive evidence of the sedimentary origin of these formations. Near the iron-bearing beds the rocks are typical greywackés and arkoses, in places finely colour-banded and with marked variations of texture across the bedding.

The fragmental beds containing elongated spindle-shaped masses of magnetite offer some difficulty of interpretation. That they are ordinary water-rolled fragments is difficult to believe. An alternative theory of origin suggested is that they represent the accumulation of magnetite grains in the hollows of ripple marks on an old beach. The magnetite-filled hollows were later covered by sand and, after consolidation, the magnetite was changed by compression into solid spindle-shaped bodies. An objection to this theory is the small number of undoubted pebbles that occur in the associated rocks. It seems likely that any beach, where magnetite sands were accumulating, would be well supplied with pebbles. Furthermore, no ripple marks have been observed on any of the bedding planes, and it does not seem likely that all trace of these features would have been destroyed by metamorphism. The production of such bodies during folding by crushing and shearing of the strata has also been considered, but there seems no reason for the localization of this action in these particular beds. Brecciation might have occurred by slumping while the material was still soft.

Another hypothesis is that the elongated magnetite masses were originally hydrated iron oxide concretions, and that they have become dehydrated and indurated during the metamorphism of the enclosing beds.

Although the sedimentary nature of the whole series may be considered certain, it is not clear that all members of it were formed by the same processes. The evidence seems to indicate that the iron-bearing beds have a somewhat different origin than have most of the rocks with which they occur. Probable methods of deposition of the iron formation will be considered in more detail when dealing with the economic geology. As for the gneisses and greywackés, the field observations and microscopic examination all point to a clastic origin. The rocks are peculiar in the almost complete absence of conglomerate or any coarse fragmental material. East of the district under discussion some conglomerate occurs in beds supposed to belong to the same series, but in the section where the chief beds of iron oxide occur no conglomeratic rock, except the peculiar type referred to in the preceding paragraphs, was observed. The original material of the greater part of the sedimentary group must have been fine-grained sands made up mostly of quartz, but, in some layers, with a considerable amount of basic clayey material from which were formed the green and grey chloritic rocks just below the iron bands and the thin beds containing green hornblende. None of the beds are continuous for long distances, but all change in character more or less suddenly along the strike. Conditions of low relief and continental or deltaic deposition must be postulated to explain such formations.

Metamorphism of the Sediments

The metamorphism that the gneisses, greywackés, etc., have undergone has been given in detail in the descriptions of microscopic examinations of the various rock types. It may be summarized here for the group in general. There has been thorough re-crystallization, producing closely interlocking mosaics of quartz individuals in all the sediments. In some of the arkoses the feldspars have undergone change to sericite, and under the intense dynamic metamorphism that has occurred along the limbs of the folds impure quartzites have been rather extensively sericitized, the foils of the secondary mineral being arranged in parallel position: where the alteration has preceded to the extreme, the rock has become a sericite schist. In the gneissic rocks, the foliation is marked by parallel foils of biotite. In some of the biotite and garnet gneisses, biotite shows some alteration to chlorite, and chlorite has formed along cracks in the garnet. Many of the gneisses are somewhat stained by iron oxide.

Succession of the Sediments

It is believed that the younger beds in this series lie to the north, and that sections from the main band of iron formation southward, cross rocks that are descending in the time scale. The strata along the south shore dip northward, but at angles nowhere less than seventy to seventy-five degrees, and hence no conclusion of relative age can be safely based on their attitude. The attitude of the minor folds of the structure is, however, significant. If any bed of the iron formation is followed eastward along its outcrop, it will be found to offset in short folds southward. The pitch of the folds is to the east at angles of forty-five degrees upward. On Island 84 the plunge of the axis is steep to the east. At the offset on the point west of Island 184 it is forty-five degrees to the east. It is evident then, that these beds are on the southern limb of a syncline pitching eastward and hence that strata lying to the southward are nearer the anticlinal axis, and so are lower than the main band of iron formation. Just how far south the anticlinal axis lies has not been determined. An anticline crosses the north end of Shikkagami lake six miles south of Lake St. Joseph, but the gneisses of this anticline are separated from the gneisses along Lake St. Joseph by a belt of intrusive granite which may have destroyed one or more intervening folds.

Similar Rocks in Adjacent Areas

Rocks similar to these sediments are described from neighbouring areas. North of Lac Seul, Burwash[1] mentions banded rocks with which considerable magnetite is associated. He favours an igneous origin for all of them, but they have a marked similarity, as shown by his descriptions, to the metamorphosed sediments in the vicinity of Lake St. Joseph.

Concerning the Lake Savant area, which lies southeast of Lake St. Joseph, Moore[2] makes the following statement: "When the rocks are compared with those of other Keewatin areas, there are a few striking differences. The most noticeable are the great amount of greywacké occurring in the Keewatin, and the presence of considerable amounts of fine-grained grey biotite gneiss, which appears to correspond closely with the gneisses described as Couchiching, by Lawson." Moore considers that part of the gneiss is derived by the metamorphism of quartz porphyry and rhyolite, and part from residual material derived by the weathering of those rocks, but he does not give the evidence upon which he decided that the gneisses are later than the quartz porphyry.

Igneous Division of the Pre=Granite Rocks

General

The igneous rocks earlier than the great granite intrusions are of two chief types, with subordinate variations. These are, (1) quartz porphyry, and (2), basic lava flows. Lamprophyre dikes and massive diorite also occur. The latter rock may be related to the same igneous activity that produced the lavas, or may be due to the re-crystallization of the lavas near the margin of the later granite intrusions.

Acidic Flows

Quartz Porphyry.—The quartz porphyry is a greyish pink or nearly white weathering rock. In some places clear quartz phenocrysts are distinctly visible in the hand specimens, but ordinarily are recognizable only with a lens. Under the microscope the rock is seen to be distinctly porphyritic, with phenocrysts of both quartz and orthoclase set in a fine-grained ground mass.

---

[1] Geological Reconnaissance, Ont. Dept. Mines Rep., Vol. XXIX, Pt. 1, 1920, Page 164.

[2] Ont. Bur. Mines Report, Vol. XIX, 1910, Pt. 1. Page 178, *et seq.*

The character and relationships of the quartz porphyry on Island 400 indicate the character and age relations. On the map the island is shown to be all greenstone, but along the western shore many small bands of porphyry are interlayered with the greenstone. From station 400G at the southwest corner of the island, northward, the following rocks are exposed:—

At station G a narrow band of porphyry, with phenocrysts of quartz and feldspar.

From station G to station A at the western extremity of the point, massive greenstone.

From A north to the bay extending eastward into the island, chlorite schist with a band of quartz porphyry, eight to nine inches wide, along the water's edge on the south side of the bay.

On the north side of this bay, a band of quartz porphyry with good-sized phenocrysts of quartz.

This is followed to the north by a band of chlorite schist, then twelve feet of porphyry with large phenocrysts of quartz, twelve feet of chlorite schist, two to four feet of quartz porphyry, and twenty-five feet of greenstone, schistose in places but showing ellipsoidal weathering, the elongation of the ellipsoids being parallel to the band. At the northwest corner of the island there are other interbandings of quartz porphyry or quartz-feldspar porphyry with greenstone, which in many exposures shows ellipsoidal weathering.

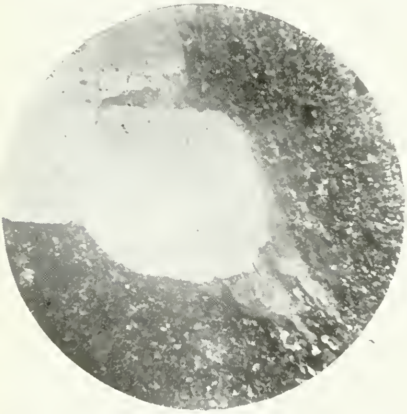


Fig. 6.—Photomicrograph of section of quartz porphyry from Island 400 showing absorbed phenocrysts of quartz. Crossed nicols × 30.

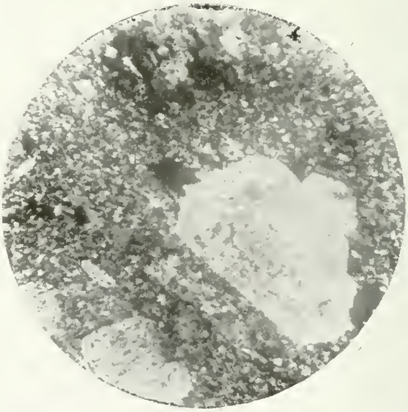


Fig. 7.—Photomicrograph of quartz porphyry from Island 400, showing feldspar phenocrysts. Crossed nicols × 30.

Samples were taken at both sides and at the centre of a band of porphyry twenty feet wide. The texture is found to vary from a dense rock at the south side to a coarse-grained rock at the north side. A similar gradation can be observed in samples from the twelve-foot band listed above. Under the microscope a specimen from the north side of the broader band appears strongly porphyritic, with phenocrysts of orthoclase, plagioclase, and quartz. The quartz crystals show some resorption. The secondary minerals are sericite, calcite, and kaolin. The ground mass consists of small quartz and feldspar grains with a distinct flow structure curving around some of the phenocrysts, Fig. 6. Microscopic examination of a sample from the south side of a band of porphyry of about the same width shows well formed phenocrysts of orthoclase, with some plagioclase. Many of the feldspar phenocrysts show distinct zonal growth. They have undergone considerable alteration to sericite and calcite, and some quantity of these minerals occurs in the ground mass which is mostly fine-grained quartz and feldspar. No flow structure can be noticed, Fig. 7.

The main differences in these samples are the greater number and size of the phenocrysts in the former, and the occurrence of quartz phenocrysts. The largest feldspar crystals are three times the diameter that any attain in the latter specimen, but the ground mass is much finer in the specimen from the north side than in the specimen from the south side. Some of these differences may be due to the fact that the samples are from different occurrences.

Quartz porphyry specimens from Island 250 are distinctly porphyritic, with phenocrysts of resorbed quartz and frayed-out plagioclase and orthoclase in a fine-grained ground mass of quartz with some sericite. The rock on Island 375 is a greenish colour on fresh fracture, but weathers to a faint pink. Quartz phenocrysts are distinctly recognizable in the hand specimen, and the microscope shows well formed crystals of orthoclase and plagioclase. The latter are twinned according to both pericline and albite laws. Much sericite has formed in elongated and connecting strings which have the appearance of flow structure.

From Island 119 grey-weathering altered quartz porphyry with irregular schistosity has rounded phenocrysts of quartz and orthoclase and stout crystals of much altered, but still recognizable, plagioclase. The ground mass consists of quartz and feldspar with calcite, sericite and considerable chlorite. A partial analysis gives SiO_2 66.22 per cent., Fe 5.01 per cent.

The quartz porphyry outcropping on Island 103 is light greenish yellow, with phenocrysts showing distinctly on fresh fractures. The microscope shows the phenocrysts to be irregular quartz individuals which have suffered some resorption and are now surrounded and the cracks in them filled by feathery, secondary minerals. The matrix is fine-grained and indeterminable, but probably consists chiefly of secondary minerals. The rock has been considerably altered.

Alteration

Much of the quartz porphyry shows a decidedly schistose structure both in mass and in the hand specimen. In large masses this structure produces platy weathering. Microscopically, rock from schistoze outcrops shows considerable alteration to sericite, and some samples are practically sericite schists recognizable as quartz porphyry only by a few quartz remnants. Highly quartzose, quartz porphyry may alter into schists very similar to those that are derived from the arkoses of the sedimentary group.

Distribution

Quartz porphyry forms the rock on many of the islands in the large central part of Lake St. Joseph west of the meridian line. It is well exposed on Islands 104, 123, 212 and many others that lie in a belt north of the islands upon which the iron-bearing beds occur. The band is broadest at the eastern end, and bends sharply north in comformity with the fold of the sediments on Island 84. An isolated mass occurs on Island 271. The main band feathers out to the westward in basic flows, and eastward is not definitely recognizable east of Island 84.

Origin

The quartz porphyry is believed to be an acidic lava flow. This conclusion rests on field relations and microscopic evidence. The microscope shows the rock to be fine-grained and porphyritic with distinct flow structures around some of the phenocrysts, Fig. 6. In the field it has been found interlayered with greenstone in relations that seem best explained by assuming that both are effusive rocks. In no place have intrusive relations of quartz porphyry into basic lavas been proved. Concerning relationships on Island 400, detailed previously, Greig, field assistant, wrote the following summary in his notes:

> It would seem that the greenstone and the porphyry were poured out as alternate flows. There is no doubt of the extrusive nature of the greenstone, for there is ellipsoidal weathering. It seems unlikely that the porphyry occurs as dikes, for there are no stringers of porphyry in the greenstone. Measuring across the strike of a series of bands, one-quarter of the exposed rock is quartz porphyry. There is no brecciation; nor are there any stringers of porphyry in the greenstone between the porphyry bands. In some places, porphyry lies between greenstone flows, one of which shows ellipsoidal weathering and the other is massive. If the porphyry were intrusive this relation could occur only if it were intruded along the bedding places between the two flows.

The main quartz porphyry band lies not far north of the northmost bed of the sedimentary group. It is assumed to be younger than the gneiss, greywacké, quartzite, and iron formation on the structural evidence given as to the order of superposition of those beds. It seems to be somewhat earlier than the greater part of the greenstone, but some of the lower greenstone flows are contemporaneous with some of the quartz porphyry flows.

Comparison with Rocks in Adjacent Areas

Quartz porphyries and rhyolites are described in the Lake Savant area by Moore.[1] Concerning them he says: "They are often highly metamorphosed and hard to distinguish from the grey, fine-grained gneiss, some of which has been developed by the metamorphism of these rocks. The quartz porphyries are light grey or pinkish in colour, and often contain distinct phenocrysts of quartz . . . . . They seem to represent the acid phase of the Keewatin eruptions, intrusive and extrusive."

This description can be applied without alteration to the quartz porphyries of Lake St. Joseph, but from evidence cited previously it seems clear that they were later than the gneiss in the northern area, and the gneiss could not have been derived through the shearing of the quartz porphyry or the consolidation of debris formed by its breaking down. It is quite true, however, in the Lake St. Joseph section, as it apparently is at Lake Savant, that sericitic quartz rocks, similar in appearance to the gneiss, are formed by the shearing of the quartz porphyry.

Basic Volcanic Rocks and Associated Schists

The basic rocks, earlier than the granite intrusion, are of four types: (1) Lava flows with which are associated some sediments. (2) Diorites and hornblendites of granitoid texture. (3) Lamprophyre dikes. (4) Pyroclastics.

---

[1] Report Ont. Bur. Mines, Vol. XIX, 1910, Pt. 1, p. 182.

Lava Flows.—The lava are fine-grained, dark green rocks or typical greenstones. In some places they retain the characteristic ellipsoidal weathering of basic flows. Under the microscope they are found to consist entirely of a felt of secondary amphibole and serpentine, with a few remnants of plagioclase feldspar. It is probable that the lavas were of medium basicity, possibly andesites. Some varieties have undergone considerable surface alteration so that, for an inch or more in depth, the rock is distinctly red and quite friable. In other places there is little surface alteration. Some of the massive, rather rusty rock found on the mainland, west of Island 276, is associated with typical greenstone, but was recognized in the field as being possibly of sedimentary origin. Microscopic examination shows the doubtful specimens to be made up chiefly of mosaics of quartz grains that seem to be undoubtedly fragmental. No area of this rock was delimited in mapping, and it is believed that the sedimentary rock is merely a local lens in the volcanic series. Dynamic metamorphism of the lavas has produced some areas of chlorite schist.

Distribution of the Lavas.—The lavas occur along the north side of the main channel of the lake. At the western edge of the sheet a narrow belt of greenstone, lying between sediments on the south and granite on the north, crosses the third meridian at Mile 1. It attains a width of a mile and three-quarters on the main land east of the second meridian, and many of the islands in the bay leading up to the eastern outlet of Blackstone lake are greenstone. North of the lake the extension of the area of rock of this kind is not known. The contact between the granite and greenstone trends nearly due north across the stream between Blackstone lake and Lake St. Joseph. North of Lake St. Joseph, however, the solid rock is concealed in all but a few places by the heavy cover of drift. These outcrops, as far north as the base line, are greenstone.

Diorite.—In the eastern part of the area, well exposed on some of the islands, there is a dark green, or green and white speckled, rock of granitoid texture. Under the microscope a granular rock from Island 6, shows green hornblende, completely altered feldspar, possibly orthoclase, and a little recognizable plagioclase. The association of this rock with granite porphyry, which is described later, makes it seem that the diorite is a hybrid rock formed near the margin of the granite batholith by reaction between greenstone and the intrusive rock. Nearly all the occurrences are not far from the granite-greenstone contact, and there seem to be gradations from fine-textured greenstone to granitoid diorite. On the other hand it is possible that the diorite may represent the interior part of thick basic volcanic flows, or that it may be an intrusive rock accompanying the lava extrusions. No attempt has been made to show the diorite separately on the map.

Lamprophyre Dikes.—Basic dikes cut the quartz porphyry. Most of them are narrow, the widest being not more than eight feet. They weather easily, commonly forming depressions in the hard rock in which they occur, and the surfaces of the dikes are deeply altered to limonite so that it is difficult to obtain fresh samples. Below the weathered portion the rock has a somewhat purple shade. with black hornblende crystals large enough to be visible to the naked eye. Samples from a three-foot dike cutting quartz porphyry on the north side of Island 123, consist entirely of secondary minerals—quartz, calcite, and serpentine—with cubes and masses of pyrite.

These dikes have not been observed in the greenstone, but it is possible that they do occur. The dark colour and conspicuous weathering of the dikes make them noticeable in the hard, light coloured, quartz porphyry, whereas they would not be so readily observed in the somewhat similar dark coloured basic flows.

Pyroclastics.—Some of the quartz porphyry shows a distinct fragmental character with lighter coloured, oval fragments, re-cemented by a somewhat darker material, which, however, is also quartz porphyry. At a locality on the north shore of the narrow channel just west of the meridian, a very striking fragmental rock contains fragments of quartz porphyry with diameters as great as four inches.

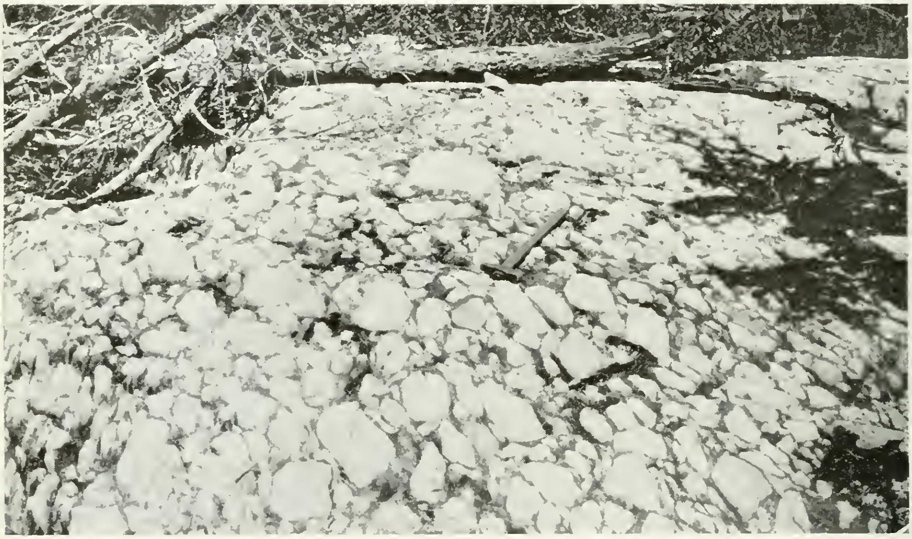


Fig. 8.—Pyroclastic rock on the north side of the narrows, Lake St. Joseph.

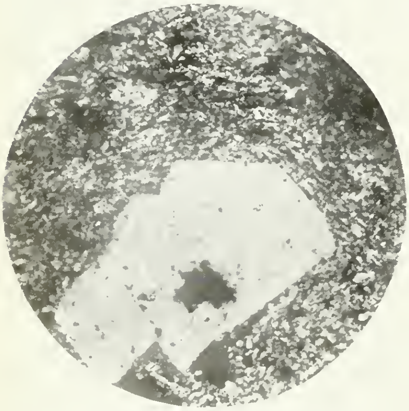


Fig. 9.—Photomicrograph of quartz porphyry fragments in pyroclastic rock, north side of the narrows, Lake St. Joseph. Crossed nicols × 30.

The matrix is dark green chlorite schist, in which the schistosity flows around the fragments. Quartz porphyry makes up the greater part of the rock mass, Fig. 8. A thin section of one of the fragments shows that the rock has undergone very little metamorphism. It is strikingly porphyritic, with well formed phenocrysts of orthoclase in a fine-grained ground mass of quartz and feldspar, Fig. 9: it is a rhyolite porphyry. The undeformed nature of the minerals in the fragments is probably due to the soft and yielding character of the matrix which has absorbed the stresses.

This rock has the characteristics of a clastic rock formed by the breaking up of an early acidic flow during the extrusion of a later basic one. Fragments of the early flow were caught and cemented in the lava, and as the temperature of extrusion of basic flows is not high there was very little absorption of the included fragments.

Age Relations of the Igneous Pre-Granite Rocks

As the sedimentary beds lie on the southern limb of the syncline the younger beds lie to the north. No repetition of formations has been recognized and the axis of the syncline is probably north of the granite-greenstone contact, unless there may be minor folds which are not truncated to a sufficient depth to expose rocks older than the greenstone. Accepting these age relationships, the greater part of the quartz porphyry is earlier than the greenstone. Some sediments intercalated in the igneous rocks were formed during local periods of sedimentation, and the passage from the early period of sedimentation to the period of dominant igneous activity was probably gradational. The diorite bosses and lamprophyre dikes may be intrusive representatives of the same magma that produced the basic lavas, or they may be differentiates or hybrid rocks formed by the intrusion of granite. The whole pre-granite period may be summarized as one of early sedimentation culminating in the deposition of the iron-bearing lenses, and a later period, chiefly of igneous activity, with acidic extrusions followed by basic flows.

Rocks of the Granite Intrusions

Rock Types

Granite Porphyry.—A porphyritic rock occurs on the northeast point of Island 10, and extends eastward across the central of Island 6. Similar rocks outcrop south of this island on the south shore. Field notes with reference to these outcrops are as follows: "The rock is fine-grained and siliceous, with zones or dikes of porphyritic rock in which feldspar forms the phenocrysts. The intrusive relation is not clear, and the porphyry may be a gradation from the diorite with which it occurs. In the centre of the porphyritic mass at the east end of the island it contains partially digested inclusions or basic segregations." Microscopic examination proves that the rock is granite porphyry, with many phenocrysts of feldspar in a fairly coarsely crystalline ground mass of quartz, feldspar, and some biotite. Sericite and other secondary minerals are abundantly developed. This rock is different from the quartz porphyry both in texture and in composition, and is believed to be an intrusive, possibly related to the granite batholiths.

Granite.—Granite occupies or underlies the surface in a large part of the map area. A large mass occupies the northwestern part of the two western townships. The southern border extends nearly east and west across the western township and then curves northward. An embayment of granite extends southward from the northwest arm of Lake St. Joseph as far as Lake 2.

The eastern edge of the granite reaches nearly to the eastern outlet of Blackstone lake. In the southern part of the map sheet, granite outcrops were observed along the first base line, and these were found by aerial observations to be part of a belt of considerable size, which extends southward as far as Shekak lake.

The granite of the northern belt is a very fresh-looking, pinkish variety. A specimen taken at some distance from the contact shows under the microscope a holo-crystalline rock composed chiefly of orthoclase, with some microcline and acid plagioclase. Quartz is abundant, and biotite and a little magnetite are present. The plagioclase has undergone some alteration to kaolin and sericite.

The granite is intrusive into greenstone, and dikes are numerous in the greenstone near the margin. The granite shows little internal evidence of the intrusion, and is practically unaltered right up to the contact; no foliation is developed in it as is the case near many greenstone-granite contacts. In the southern belt there are more evidences of reaction between the granite and greenstone, and, in places, there is some foliation.

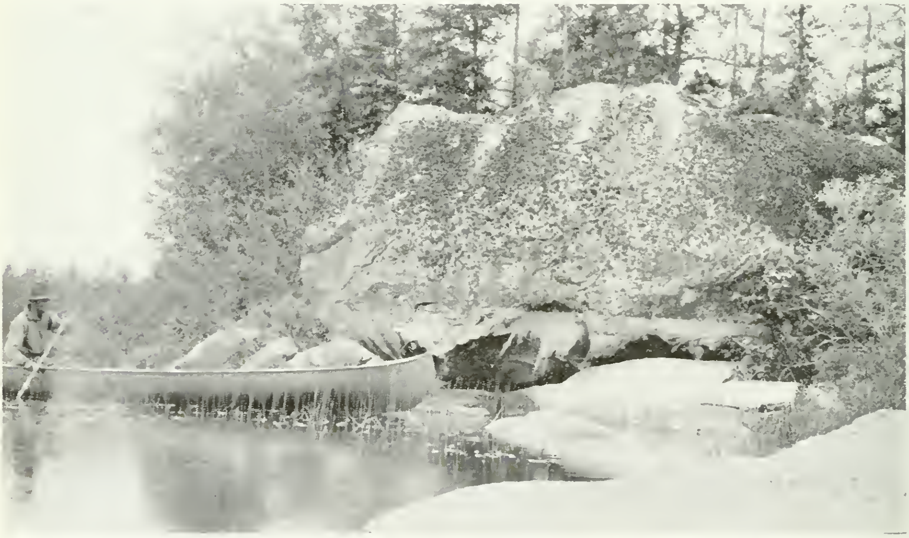


Fig. 10.—Glacial boulder of granite on the shore of Blackstone lake.

Pegmatite Dikes.—Pegmatite dikes are developed very abundantly in the gneiss along its southern margin. In general, they consist of pink feldspar and white quartz with considerable muscovite and some biotite. In many of them black tourmaline has crystallized out along the margins. One crystal of beryl was found. The pegmatites are no doubt related to the granite intrusion to the south. It may be considered an additional indication of the structure of the region that the dikes occur abundantly near the southern granite mass, less abundantly in the northern part of the sedimentary area, and that few are found along the northern border of the gneiss, even where the distance to the northern granite mass is not great. No typical pegmatite was found in the greenstone.

Age Relation of the Granite

The granite is the youngest pre-Cambrian rock of the region. It is much later in age than the other pre-Cambrian rocks, the sediments having been laid down and consolidated and the lavas poured out and solidified long before the batholithic invasion. The granite was associated with the regional disturbances that produced the close folding. Great thicknesses of overlying formations have been removed to expose the granite cores of these early mountain chains.

Glacial Formations

In this region there are no rocks belonging to the long period of time between the pre-Cambrian and the Pleistocene. If any such ever existed they have been completely removed by erosion. The formations of the Pleistocene are unconsolidated glacial deposits, chiefly of sand, containing some boulders, and only a small quantity of clayey material. In the areas underlaid by granite the prominent jointing provided conditions for easy removal of large rock masses by the moving ice, and some immense boulders are found along the shores of Blackstone lake, Fig. 10. These have not been moved any great distance.

Glacial erosion is well marked along the lake shore where fresh rock surfaces are exposed. The gneissic rocks have not retained many evidences of glacial action, but glacial striæ are visible on many of the granite surfaces. The signs of glacial erosion are not as abundant or as striking as they are in many sections of the pre-Cambrian shield, and it seems likely that, for long periods the ice was almost stagnant, and that this area was the site of dedeposition, rather than of extensive erosion. This is borne out by the typical terminal moraine character of the glacial deposits. Wherever glacial striæ were observed, they have the southwest trend of the Patrician glacier.

The surface upon which the glacial deposit rests is remarkably fresh. Differences of relief are small. The fresh pre-glacial surface with comparatively small differences of relief even in heterogeneous rocks, could not have been produced by the comparatively weak erosion of the Pleistocene ice. It was no doubt formed long before that time. There is no evidence in this area to fix the date of the planation, but it was probably pre-Paleozic, as has been shown to be the case in other sections of the Canadian shield.[1]

Recent

Since the glacial period the chief changes are the rearrangement of the glacial deposits and the growth of peat bogs in undrained areas. Along the lake shores the ridges of sand and gravel are being continually cut into by the waves. The eroded material is carried along the shore by the currents and deposited as sand bars and spits. These have been discussed in a previous paragraph. Peat bogs are not extensive. Where gneiss is the underlying rock, swampy country may extend for considerable distances parallel to the structure, but such areas are narrow. So much of the glacial material is sand that there is fairly good drainage wherever the solid rock is covered with glacial deposits. Marshes border some of the lakes and the sluggish streams.

---

[1] Memoir 105, Geol. Surv. Can.

Geological History

The geological history indicated by the formations just described begins with an early period of ordinary sedimentation in a country of comparatively low relief, so that the sediments consisted chiefly of sandy material with practically no coarse fragments. At various times conditions in restricted basins were favourable for the accumulation of iron-bearing beds. The area affected by these conditions was small, and the time during which they existed was short during the early part of the sedimentary epoch, but towards its close large areas of this kind existed for periods sufficiently long to form beds of iron minerals some hundreds of feet in thickness. The conditions of deposition of these sediments, high in iron, will be dealt with in more detail later.

After the deposition of the main iron-bearing beds came the beginning of volcanic activity. The first lavas extruded were acidic in character and comparatively small in quantity. The later acidic flows alternated with basic lavas, and finally only basic lavas were poured out. Many of the basic flows have typical ellipsoidal forms which are usually assumed to be the result of extrusion under water. Along with the volcanic effusions there were formed some ordinary clastic sediments, probably in local basins.

The extrusion of the lavas, possibly accompanied by the intrusion of deep-seated rocks of similar composition, closed the first great epoch of geological history. It was followed, after the lapse of sufficient time to thoroughly consolidate the clastic rocks, by intense disturbances, which threw the formations into closely appressed east-west folds pitching to the east. These disturbances were accompanied or followed by the intrusion of igneous rocks. Great batholithic masses of granite welled up along the axes of the folds, intensely metamorphosing and disturbing the overlying rocks. Narrow lamprophyre dikes are evidence of igneous activity, the age of which is not definitely known; they may belong to a pre-granite period, but their undeformed character indicate that they may be differentiates in some way associated with the granite. Pegmatite dikes mark the closing period in the consolidation of the granite.

After the igneous intrusion and the structural deformation with which it is associated, there was an immensely long erosion interval in which the heterogeneous early rocks and the granite were cut down to a fairly level plane which, it is believed, did not differ very greatly in appearance from the present solid rock surface. No rocks of any age between the pre-Cambrian and Pleistocene remain, but assuming that this portion of the Canadian shield has the same general history as other parts of its southern edge, it is likely that Paleozoic and possibly Mesozoic formations at one time covered part, if not all, of the pre-Cambrian rocks. If these later formations did exist, they were completely removed before the advance of the Pleistocene glacier. The chief work of the Pleistocene glaciers was the removal of unconsolidated and weathered debris from solid rocks. Later, the stagnant ice front permitted the deposition of immense quantities of largely unassorted glacial debris. Since the ice age there has been some rearrangement of the glacial sands and gravels and the formation of organic deposits. These processes are going on at the present time.

Economic Geology

History of Prospecting

The chief economic interest in the Lake St. Joseph country is in the beds of iron oxides. It seems strange that though the beds are close to the main route of travel, followed by the Hudson's Bay Company brigades and all other travellers down the Albany river, no one mentions actually having seen iron-bearing beds. Even the early geological report of Dr. Bell[1] does not mention such an occurrence, nor does the writer note any abnormal local magnetic attraction. In the report of the geologist attached to the Ontario Exploration Party No. 9, the following note is made.[2] "At sixteen miles (from Root portage) chlorite or hornblende schist occurs along the shore. An area of great magnetic variation extends for ten miles down the schist; no apparent cause was found as the adjoining schist showed no traces of magnetite. At one point the variation was 65°." It is possible that the schist which showed no magnetite was that along the south shore south of Island 84. The magnetite occurrences are on the south shore of the island and bend back to the east beneath the channel separating it from the south shore. These beds under the lake attract the needle all along this passage although exposed only on the islands, Fig. 11.

Photograph by courtesy of the Air Board of Canada

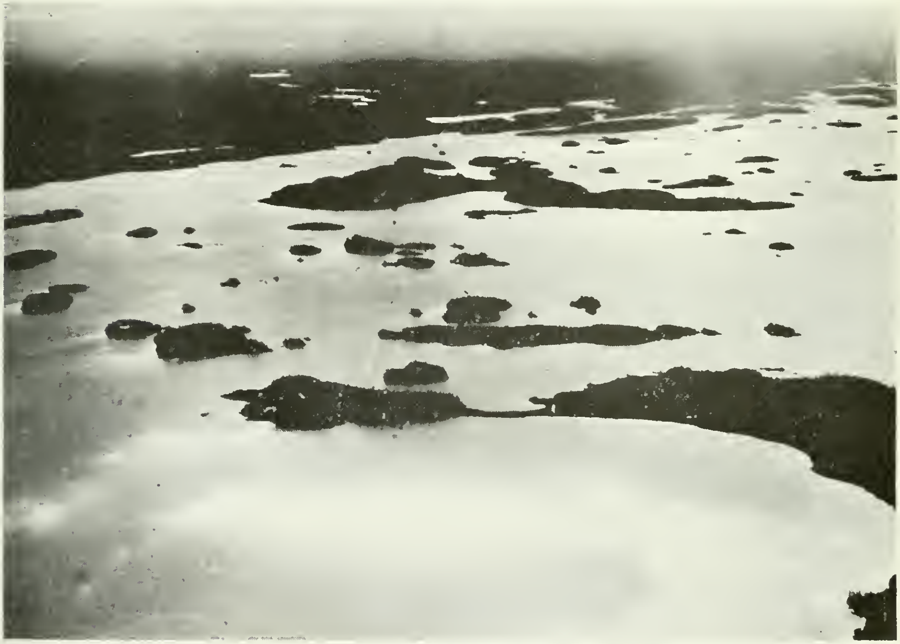


Fig. 11.—Part of Lake St. Joseph from an altitude of 2,500 feet, looking southwest. Island 84 is the irregular island in the centre of the picture. Island 162 is the long island beyond Island 84 near the south shore.

---

[1] Annual Report Geol. Surv. Can. New Series, Vol. II, 1886.

[2] Report of the Survey and Exploration of Northern Ontario, 1900, p. 249.

Some of the men connected with the Hudson's Bay Company posts along the Albany river knew of the deposits and claims were staked by Jabez Williams, formerly in charge of Lac Seul post, now at the post at Fort Hope on the Albany. Chiefly through his enterprise a diamond-drilling outfit was sent in from Port Arthur. Island 162 was chosen as the place for testing the beds, and a considerable amount of drilling was done. A hundred feet or more of drill core still remain in the cabin on the island, and no doubt the better portions were taken out for assaying. The walls of a cabin apparently belonging to prospectors of an earlier period are still standing on Island 84, but the only trace of development work found was a few clearings near some of the outcrops.

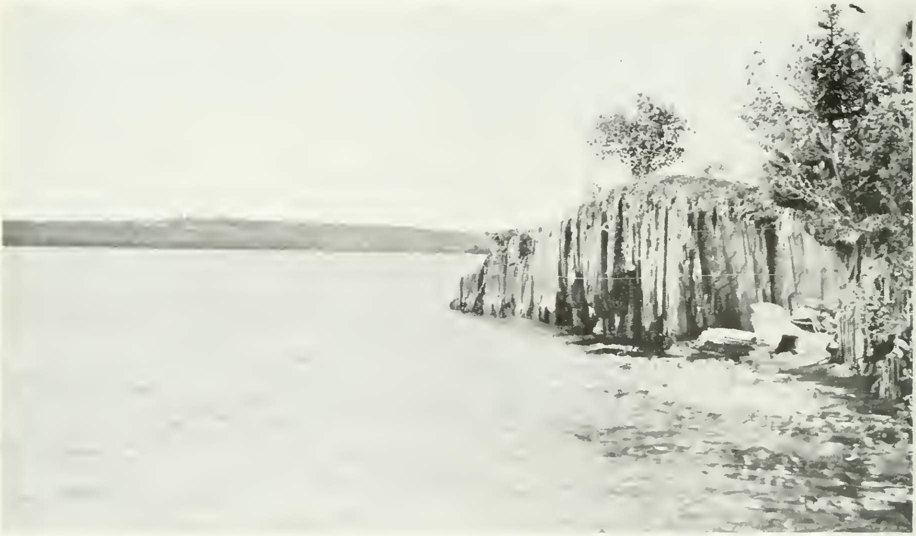


Fig. 12.—Outcrop of iron formation on Island 84, showing the platy structure formed by weathering in schistose rock.

Iron Formation

Character of the Iron Occurrences

Although the iron oxides are associated with sediments and form part of a great sedimentary series, the actual occurrence of the bodies of iron oxides is lenticular in character. Due to folding, various parts of the same lens have undergone different degrees of metamorphism, and hence what were originally similar portions of the lens, are now somewhat unlike both in physical and mineral make-up.

Mineralogy of the Iron Formation

The minerals in the iron layers are not of great variety. In the contorted beds at the crests of the folds, the iron is almost entirely in the form of magnetite, interlaminated with some quartz, but chiefly with lenses of rock material of varying thickness. Along the limbs of the folds where the movements of the beds with reference to one another was greatest, there is usually little visible foreign material, and the whole lens appears to consist of strongly schistose magnetite, Fig. 12, and specular hematite, which is in many cases micaceous in structure. On microscopic examination and chemical analysis it is shown, however, that there are quite large proportions of silica mixed with the apparently pure iron oxides. No apatite or titaniferous minerals have been recognized either on polished surfaces or in the ground minerals, but the analyses of samples from different localities all show considerable quantities of phosphorus and traces of titanium. Small, transparent, deep red garnets, with sharp crystal outlines, were found embedded in magnetite from the eastern part of Lake St. Joseph. The crystal form is the unmodified rhombic dodecahedron.

Associated and Interbedded Rocks

The rocks associated with the iron oxides are all clastic, most of them with a high percentage of silica. The following petrographic descriptions are of the various rocks interbedded with, or in direct contact with, lenses of iron oxides.

A specimen of rock lying between bands of iron oxide on Island 84 consists chiefly of carbonate with some chlorite and many rounded grains of quartz. A partial chemical analysis shows SiO_2 40.04 per cent., and iron 7.02 per cent. The carbonate does not effervesce with cold acid and so is probably dolomite or ankerite. At the southeast corner of the same island rock material is interlaminated with iron oxide, jasper, and quartz. A specimen of the rock under the microscope appears fine-grained and highly siliceous, with the quartz recrystallized into mosaics. Well-crystallized magnetite is present, commonly associated with chlorite. Biotite and sericite are abundant, and the foils are in parallel position. A specimen of rock from the iron-bearing beds of the north part of the same island has rounded fragments of quartz with some orthoclase and plagioclase. The ground mass is schistose consisting of sericite. Biotite is present as well, but the foils are not parallel to the schistosity, and it may have developed subsequent to the foliation. On Island 98 a yellowish green, granular rock lies north of a band of fragmental or nodular iron oxides. The rock appears distinctly foliated under the microscope, and consists chiefly of rounded quartz grains that show secondary enlargement, and some plagioclase. A partial analysis shows silica 72.3 per cent., and iron 6.32 per cent.

Rock occurring near the iron beds on the north side of Island 133 consists of a few larger particles of plagioclase of fairly acid character, which look like phenocrysts. The finer material is mostly quartz and fragments of plagioclase with considerable secondary quartz and some calcite. The origin of this rock is somewhat doubtful. The field evidence seems to show that it is a fragmental rock, possibly a greywacké, but under the microscope, it has some of the characteristics of a sheared igneous rock.

Well-banded rock noted on Island 158 contains some narrow bands of magnetite. The widest is not more than two and one-half inches. Microscopically, the rock appears granular, with large rounded or subangular quartz individuals showing secondary enlargement, set in a ground mass of finer texture which is mainly quartzose but contains some calcite and epidote. Many of the largest quartz fragments show strain shadows and others have been actually fractured, and the cracks filled with the finer material of the matrix. The rock is apparently an arkose which has been rather severely sheared.

Origin of the Iron-Bearing Beds

The descriptions given above show that the beds containing magnetite and hematite are interlayed with typical sedimentary beds differing from the ordinary sediments, not directly associated with iron-bearing beds, only in that they carry considerable amounts of carbonates, probably of iron. There are also some beds of conglomeratic character in which nodular masses of magnetite are found. From this association it might be assumed that the iron minerals are sedimentary in origin, but before accepting this conclusion definitely other hypotheses of the origin of bedded magnetite deposits should be considered. The following are possible methods of formation: (1.) Contact metamorphism. (2.) Clastic sedimentation. (3.) Chemical precipitation.

Hypothesis of Contact Metamorphism

Contact metamorphism has been established as the probable method of origin of many bedded magnetite deposits. The ores of such deposits are usually coarse in crystallization, and the magnetite has associated with it typical contact metamorphic minerals such as garnet, epidote, and usually pyrite. Deposits in bedded rocks may follow certain favourable beds for long distances, but they are more likely to be rather irregular. It is usually the case that contact metamorphic deposits are fairly close to igneous rocks which have supplied the conditions necessary for re-crystallization, and which have in most cases furnished part of the material for the deposits.

The Lake St. Joseph deposits are distinctly bedded, but are lenticular. Each bed is confined to a certain horizon, and gradually feathers out into non-iron bearing rocks. The change does not seem to be the result of any variation in an original bed producing less favourable conditions for replacement. In the carbonate-bearing rocks the iron is contained in the carbonate. It is not a replacement of carbonate by magnetite. Contact metamorphic minerals are not common in the iron-bearing beds. Garnet is found in some samples of magnetite, but it has the appearance of crystallization from impurities contained in the magnetite, and does not seem to have been formed by additions from an outside source to the minerals of a pre-existing formation. The garnet does not occur as zones or masses, but only as scattered, well formed crystals.

The granite is the only great intrusion in the area. If the iron formation were of contact metamorphic origin, it would be expected to occur fairly close to the contact of the granite batholith with the older rocks. The main beds of iron oxide occur in the district mid-way between the two great granite intrusions. No magnetite bands were found anywhere near the northern granite belt, and there is no marked local attraction in that section. On the south shore of the lake some magnetite bands occur in the gneisses between the main magnetite band and the belt of granite: none of these is of large size and the lenses become less numerous and smaller in size proceeding southward. From these facts it is concluded that the iron formation is not of contact metamorphic origin.

Hypothesis of Clastic Sedimentation

The occurrence of bedded deposits of iron oxides interlaminated with clastic sediments would seem to be most simply explained by assuming that the magnetite was laid down with the other sands, as it sometimes accumulates along modern beaches. There are several features, however, which do not seem to agree with this theory. The magnetite of the Lake St. Joseph deposits is fine-grained, and the grains are not rounded or flattened but quite angular. Much of the angularity is no doubt due to re-crystallization, but it seems doubtful that all the original rounded grains of magnetite would have been re-crystallized into angular ones. In the second place, a clastic deposit would contain not only magnetite and quartz, but other heavy minerals that occur along beaches, such as garnet, titanite, apatite, etc. Garnets occur in the magnetite as noted previously, but only rarely and then as sharp, well-formed crystals, not as rounded grains nor as lenses as might be expected if the garnet were detrital. Titanium occurs only as traces in any of the ores analyzed, and hence the heavy and resistant titanium minerals, which are present in most sand deposits, are almost entirely absent. If the iron formation and the interlayered greywackés, arkoses, and gneisses are all clastic, then all the beds might be expected to contain considerable amounts of magnetite as water-rounded grains. Magnetite does not occur abundantly in any but the main beds, and there are no intermediate types between the lenses of high iron content and beds practically without magnetite, with the exception of those conglomeratic beds, in which the magnetite looks like rounded pebbles but is actually in the shape of flattened cylinders or spindles. The explanation that has been offered for these is that they may be concentrations of magnetite sand in ripple marks, but from the character of the grains they are more likely concretionary. Finally, the small included lenses of rock, which consist largely of carbonate, are evidence that different conditions prevailed during the deposition of the iron-bearing beds from those present during the formation of the other sediments. Jaspery lenses are further proof of this, although jasper does not occur in large quantity.

Hypothesis of Chemical Precipitation

The theory of formation by chemical precipitation explains the characteristics of the ore more satisfactorily than do the preceding hypotheses. It explains the fine-grained character of the oxides, the association with jasper and iron carbonate, the absence of heavy detrital minerals scattered through the ore, and the scarcity of magnetite in beds other than the main iron-bearing members. Assuming that chemical precipitation was the mode of formation, various conditions of deposition may have obtained. The original minerals may have been iron silicates or iron carbonates, as is held for many of the Lake Superior iron deposits; the original mineral may have been hematite, as in the Clinton ores; or the iron may have originally separated as hydrated iron oxides.

In the Lake Superior region the deposition of iron-bearing minerals is believed to have been preceded by the effusion of basic lavas beneath the sea, so that the water became saturated with iron salts. From this sea of abnormal chemical constitution and probably fairly high temperature, iron silicates such as greenalite were deposited. Later, under ordinary weathering conditions, the silica was leached from the greenalite in favourable localities where there was a concentration of the ground water along certain channels. In this way the iron oxides were left as enriched residual material along the axes of synclines or in structural basins of other types.

That such conditions did not exist at Lake St. Joseph is shown by the following facts. No iron silicates have been recognized in any of the sections examined. It is possible that they may have been overlooked, or that the samples collected did not happen to be from the proper locality, but the microscopic examination is borne out by the low iron content in the sediments, and the samples are fairly representative of the various beds. The lenticular character of the Lake St. Joseph deposits is original, whereas the lenses of the Lake Superior region are due to secondary leaching, usually at the axes of synclines. The lenses of magnetite at Lake St. Joseph are not synclinal but, neglecting the minor folding, they lie along the limb of a major syncline. Hence they are not structural features formed after the folding, but were prior to it and probably original. If so, there seems to be no reason to suppose that they are alteration products from a bed of iron silicates unless such a bed be assumed also to have been lenticular. Finally, the basic lavas in the vicinity of Lake St. Joseph are above the iron formation and, being later, could not have supplied their iron content. It is possible that flows contemporaneous with, or earlier than, the iron formation, may have existed in other districts sufficiently near to have supplied the iron solution for the Lake St. Joseph deposits. They did not exist beneath the gneisses and arkose of the local sedimentary series, for in that case the iron formation would have been at the base of the series instead of near the top. Thus, the absence of iron silicates, the original lenticular nature of the magnetite beds and the absence of earlier basic lavas which might have supplied iron solutions, are indications that the iron formations were not directly derived from subaqueous lava flows.

The Clinton beds are believed to have formed by the direct precipitation of hematite in sea water. As there is a considerable quantity of hematite with the magnetite in some of the occurrences at Lake St. Joseph, it might be assumed that they were originally deposited as hematite and later altered to magnetite during the deformation of the region. On such an assumption the most complete alteration to magnetite should occur in those places of greatest compression and movement. The opposite condition is found. At the crests of the minor folds, the iron is chiefly in the form of magnetite, and along the limbs where the greatest differential movement has occurred a large proportion of specular hematite is found. From theoretical considerations it is doubtful if hematite would be altered to magnetite by regional metamorphism. It would appear that the elimination of oxygen should reduce the volume and hence that hematite should alter into magnetite under compression. There is, however, a difference in specific gravity between specularite and magnetite sufficient to off-set this and to make it more probable that, under pressure alone, specularite and not magnetite is the stable oxide. This agrees with the field evidence.

A third mode of origin to be considered is deposition as hydrated iron oxides or as carbonate. Hydrated oxides are commonly deposited at the present time in bogs receiving the drainage from iron-bearing rocks. Such an origin would explain the lenticular character and the freedom from detrital material in the iron minerals. It would also explain the spindle-shaped magnetite masses in the conglomeratic beds. There is, however, a question whether iron carbonates or hydrated iron oxides would be precipitated without organic agencies, and these, if present at all, were probably not abundant at this early period. Aside from this possible theoretical objection, the above hypothesis explains most satisfactorily the observed facts, and as it does not seem impossible that these minerals can be formed by chemical action alone, this is concluded to be the method of formation of the original iron-bearing beds. The history of the deposition may be summarized as follows. There were certain basins in the old land surface at various times in which iron-bearing solutions obtained by the ordinary weathering of the surrounding rocks were collected, and from these solutions iron hydrates or iron carbonates were precipitated. Occasional periods of flood brought in some clastic material, now found as lenses of rock. At the edges of such basins this was most common and so the fingering out of the iron ore lenses into iron-bearing clastic rocks is explained. The abundance of iron beds, and the greater thickness near the top of the sedimentary series, may have been the result of longer periods of deposition, or possibly of the beginning of volcanic activity in some district tributary to the basins of precipitation. It is not believed that carbonates formed a large part of the original beds, for the amount of carbonate found at present is small, and it does not seem to have undergone much alteration to oxides. The change from hydrated oxides to magnetite and hematite could easily result through the regional disturbances. The form of the oxide would depend upon local conditions.

Comparison with Lake Savant Occurrences

Iron formation which occurs at Lake Savant has been examined by E. S. Moore. His conclusions are similar in some respects to those reached for the Lake St. Joseph occurrences. Judging from Moore's descriptions the Lake Savant occurrences have a larger proportion of jasper to iron minerals. Concerning the genesis of the iron oxides Moore says:[1]

> There are, no doubt, plenty of igneous rocks in the region to supply the ore, but their relations to the jaspers do not seem to indicate them as the source. Instead of the igneous rocks being interbanded with the iron formation, the latter is made up of large quantities of greywacké, evidently derived from the partial decomposition of the igneous rocks. If the igneous rocks supplied the iron solutions to the seas there should be greater regularity in the distribution of the iron formation, a smaller proportion of imperfectly water-worn sediments, and a closer relation between the igneous rock and the jasper. For the Savant region it appears that conditions favour deposition in bodies of water of limited size and surrounded by land areas capable of furnishing the material for the greywacké. The source of the iron must have been chiefly the igneous rocks which were decomposed, supplemented to some extent by solutions supplied directly to the bodies of water by heated igneous rocks. The iron formation must have reached its present condition through extensive metamorphic processes by which rearrangement of the iron and silica took place, emphasizing the banded formation and changing chert from a crypto-crystalline to a granular crystallized mass . . . . . The earliest iron compound, the remains of which may still be recognized, seems to have been the carbonate, which is now very largely altered to magnetite by excessive metamorphism, while the quartz seems to have originally been in the form of chert.

There are some conditions in the deposits of the Lake St. Joseph area that do not fit, exactly, the hypothesis suggested by Moore. The igneous rocks are later than the iron beds, and so could not have supplied even a part of the iron solutions directly, nor could their decomposition have furnished the debris for the greywackés. The earliest rocks exposed are clastic sediments, and the source of supply of the constituent minerals is unknown. There seems to be no reason to assume that the crystallized quartz with the iron beds at Lake St. Joseph was originally cherty. It was probably ordinary sand interbedded with the original iron minerals and later altered into mosaics of interlocking quartz individuals. Some carbonate has been found with the magnetite-hematite beds, but there is no evidence that all the iron, or even any large amount of it, was originally in the form of carbonate. In fact, the carbonate in the samples examined has more the appearance of being itself secondary. Aside from these points, the explanations offered for the origin of these similar beds in the two adjacent areas are practically the same.

---

[1] 19th Annual Report, Ont. Bur. Min., 1910, Pt. 1, page 189.

Composition of the Deposits

The fine-grained character of the magnetite conceals much of the foreign material which it contains. At the axis of the folds there is a considerable quantity of interbedded quartz, jasper, and rock, but along the limbs, the beds have been sheared into tabular blocks which consist of magnetite with enough specular hematite to give a red streak, but no other minerals are recognizable in the hand specimen. It is found on crushing that there is a large amount of gangue, mostly silica, even in the best samples. Specimens can be chosen which give a fairly high content of iron. In attempting to estimate the value of the lenses, portions were selected which seemed to be of good grade and which were also sufficiently large to give workable tonnages, if the content of iron should be found to be sufficiently high. Chipped samples were taken across such outcrops, and the following results may be considered to be averages of some of the most promising occurrences.

	14	15	134	135	165	172	173
Fe	32.60	34.94	38.42	36.32	34.4	37.7	37.92
S			none	none			none
P			0.1209	0.1564			0.2305
Ti			trace	trace			trace

No. 14. Channel sample across 15½ feet at the south side of the iron-bearing band along the northwest side of Island 84 at a point opposite Island 131.

No. 15. Channel sample across 16½ feet of the north side of the iron-bearing band at same locality as No. 14. The two samples are continuous, making the total width sampled 32 feet.

No. 134. Channel sample from the ridge of iron formation north of station C on the south shore of Island 84. Width of the beds at this point is 375 feet. The size of the individual outcrop where the sample was taken is 50 feet by 200 feet. Width sampled 30 feet.

No. 135. Channel sample across a width of 25 feet parallel to number 134, and thirty feet east.

No. 165. Channel sample across 35 feet of iron formation high in magnetite, two chains inland from station C, Island 84. This outcrop is much contorted and contains considerable jasper.

No. 172. Channel sample across 40 feet of iron formation north of the cabin on Island 162.

No. 173. Channel sample across 32 feet of iron formation at the same locality as No. 172. The south end of sample 173 is 25 feet north of the north end of 172. The two samples make a total width sampled of 72 feet but 25 feet of lean rock between the ends of the two channels was not sampled.

A report by Prof. S. N. Graham, of mill tests made on two samples of ore, at the mining laboratories at Queen's University, is as follows:

> The ore consists of a very fine-grained and intimate mixture of magnetite, hematite and silica. Preliminary tests showed that very fine grinding was necessary to make any separation of the iron minerals from the silica. Tests were then made by wet magnetic concentration on a drum machine of the Gröndal type. In making the tests the tailings were re-run, and concentrates produced were added to those made in the first run. The sand tailings contained a small amount of weakly magnetic material, which probably consisted of grains partly of magnetite and partly of hematite. The overflowing slime was of a deep red colour, due to the hematite.
>
> The following are the results of the tests:—

Sample No.	Analysis of Iron ore	Degree of grinding, through 200-mesh	Analysis of concentrates Iron	Ratio of Concentration	Total Iron Recovered
165	34.4	75	45.2	1.92 to 1	68.3
"	"	100	56.8	2.44 to 1	67.7
172	37.7	75	47.4	1.82 to 1	69.2
"	"	100	59.5	2.27 to 1	69.4

Depth of the Deposits

The greatest length of ore that may be considered to be a continuous lens is the main band that is folded to form Island 84. This is found as a series of lenses on Island 162. Eastward it bends back beneath the lake and can be traced by magnetic disturbances to a point between Island 17 and the long sand point on the south shore. This is a total length of nearly five miles. Owing to the plunge of the folds it may be assumed that the beds continue down the dip at least half the distance that they can be followed on the strike. This assumption is based on a supposed circular form for the original basin and the truncation of the tilted beds approximately along a diameter of the basin. If this be granted the depth to which the lens may be expected to continue at Island 84, assuming an average plunge of the fold of 45°, is something over two miles.

Possibility of Enriched Lenses

In the Lake Superior deposits the original iron minerals have been altered and the iron content increased by leaching by downward moving surface waters, and as a result, in certain structural basins, there occur great bodies of high-grade residual iron ores. Some have assumed that iron formation of the type found at Lake St. Joseph may have been enriched in similar fashion, and that synclines will be found to contain ore bodies. Further, the impression has become current that lake basins are structural hollows and so should be underlaid by deposits of iron. The differences between the iron ore bodies of Lake Superior and those of Lake St. Joseph are fundamental. The Lake Superior bodies were leached by surface waters either soon after deposition or at any rate while still near the surface. The Ontario deposits were not affected by an erosion period following the deposition of the sediments, but so far as can be seen the period of sedimentation graded directly into the period of igneous extrusions. That is, the iron beds were covered almost immediately after deposition, and there was no opportunity for surface alteration or lateritization. They were again exposed only after a very long period, and after the folding of the region had been accomplished. This disturbance compressed the whole series into synclines and anticlines, and metamorphosed the original iron minerals into dense magnetite and hematite, associated with the fine-grained quartz. There is little possibility of the leaching of material from this fine-grained aggregation along the exposed edges of the up-turned beds, and the iron-bearing beds show none of the porous structure which they should exhibit had they undergone any such alteration. So far as the possibility of deposits in lake basins is concerned, there is no evidence to support such an assumption. The magnetite beds mostly form ridges. Some parts of them are beneath the lake but this is probably due to causes other than the physical character of the iron formation.

Possibility of Concealed Lenses of Magnetite

In most places the magnetite occurrences are well exposed, but in that part of the area covered by terminal moraine, sand and gravel conceal even the ridge-forming rocks. Traverses with the dial compass and dip needle were made at closely spaced intervals in the section south of Lake St. Joseph. Little magnetic disturbance was found, and there is not much likelihood of hidden lenses of any importance.

Quartz Veins

Many stringers and veins of quartz occur in the granite, but none of these were sampled. Veins of any workable size in rocks earlier than the granite were sampled, and assays of two of these were made at the Provincial Assay Office, Toronto, with the following results:

	No. 31	No. 36
Gold	none	none
Silver	2.08 oz. per ton	none

Sample No. 31. Sample chipped across a series of quartz veins on the northwest side of Island 34. Total width of quartz is four feet in a zone twenty feet wide.

Sample No. 36. Sample chipped across a quartz vein seven chains inland from the lake south of Island 84. Width of vein—ten feet. length exposed—100 feet.

No large veins were seen in the greenstones. The rock association with granite intruding basic rocks should have been favourable for the formation of gold-bearing quartz veins. If such occur anywhere in the district the greenstone areas east and west of the granite embayment along the north side of Lake No. 2 should be an exceptionally favourable locality for prospecting.

EASTERN PART OF LAKE ST. JOSEPH

By E. L. Bruce

Introduction

The following preliminary report deals with an area lying east of that covered by the report on "The Iron Formation of Lake St. Joseph." Townships were blocked out south of the lake by J. S. Dobie, O. and D.L.S., during the season of 1921, and the whole south shore of the lake as far east as Osnaburgh Indian Reserve and a part of the north shore were surveyed by him. The second base line was run east from Mile 66 on the primary meridian, and meridians were run north every six miles, from the base line to the lake shore. Bays from the main lake cross the base line between Mile 10 and Mile 12 and just west of Mile 14. The large bay southwest from Osnaburgh House extends nearly to the base line at Mile 22.

Rock outcrops along the shores were examined with considerable care, and the surveyed lines were traversed. Exposures are too scattered to attempt to make a complete areal map, and only actual occurrences of rock seen are shown on the map accompanying this report. No traverses inland were made other than those on the surveyed lines, both because of lack of time and because the small areas of solid rock to be seen did not seem to justify closely spaced sections.

Summary

The general character of this section is very similar to that to the west. There seems to be less burned country than in the western area, and some sections of very good pulpwood are to be found. The geology of the district is comparable to that of the west, but as much of it lies in the terminal moraine area. less rock is exposed. Iron formation is found, but the beds are much thinner than those of the western district and are not of workable size.

Timber

The best area of pulpwood seen anywhere in the vicinity of Lake St. Joseph is along the meridian running north from Mile 18 to the lake. Good timber extends eastward along the base line for about a mile east of the meridian. Westward there is no burned country as far as the lake at Mile 14. Unburned areas were seen north of the lake, but no examination of any of that part of the country was made.

Geology

The rocks belong to the same geological groups as those described in the report dealing with the western part of Lake St. Joseph, but there is some modification in the various types. The relations are expressed by the following table:

TABLE OF FORMATIONS

Age	Relations	Rock Type
RECENT		Peat
GLACIAL		Clay, sand, gravel
	Unconformity	
PRE-CAMBRIAN	GRANITE AND OTHER INTRUSIVES	Pegmatite dikes, granite, hornblendite and diorite, lamprophyre dikes.
	Intrusive Contact	
	PRE-GRANITE COMPLEX	*Igneous Group*— Greenstone, chlorite schists. *Sedimentary Group*— Iron formation, biotite-garnet-gniess, staurolite schist, quartzite, arkose, conglomerate.

Pre=Granite Complex

General

The rocks older than the igneous intrusions associated with the granite batholiths are grouped into a lower sedimentary series and an upper igneous series, although in this area there is little conclusive evidence of the relative ages. The sedimentary group consists of garnet-biotite-quartz gneiss, quartzite, arkose, and magnetite beds. There are many occurrences of garnet and staurolite schist and one of conglomerate. The igneous group is not important areally. The rocks are massive greenstones, but are not ellipsoidal, and some of them may be highly altered greywackés.

Sedimentary Group

Conglomerate.—Outcrops of conglomerate are crossed by the base line east of the twentieth mile post. The first bed is two chains east of the post. It is 10 feet thick, and contains well rounded pebbles of granite, quartz and bluish chert in a granular siliceous matrix. Conglomerate is interbedded with rusty weathering mica gneiss 7 chains east of Mile 20. The beds vary in thickness from two inches to 2 feet. Granite lies directly west, but not in direct contact with the conglomerate. Pebbles of granite in the conglomerate might lead to the inference that there is an unconformity, but it is believed the granite is younger, as it is found intruding the gneissic rocks on the meridian north from Mile 18, along the base line at Mile 22 + 25 chains, and at various points along the shore of the lake north of that part of the base line.

Other Sedimentary Rocks.—Gneisses of sedimentary origin are the most commonly exposed rocks. Large areas of garnet gneiss extend from the base line between Mile 20 and Mile 22 + 25 chains northward to the lake. Light pink garnets make up a large proportion of the rock mass. Staurolite schist is interbanded with garnet gneiss in many places. The crystals of staurolite are an inch or more in diameter, and form the greater part of the rock. Both single crystals and twin crystals are found. They are not parallel to the bedding, and have evidently formed subsequent to the folding of the rocks. The matrix in which they lie is largely sericite. Quartzite was observed at some localities along the shores of the bay crossed by the base line between Mile 10 and Mile 12. Some of these are brecciated, with the fragments recemented by quartzite. Under the microscope they appear to be typical quartzites with rounded grains of quartz, some feldspar, and sericite as an alteration product, Fig. 1.

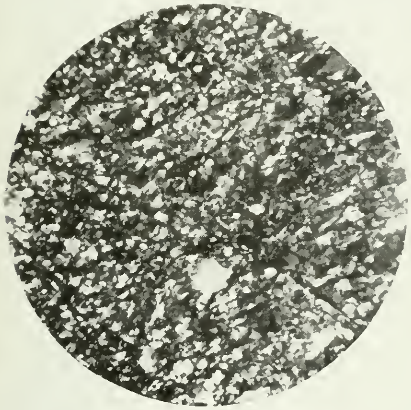


Fig. 1.—Photomicrograph × 30 of quartzite from the south side of the bay crossed by the base line between Mile 12 and Mile 14, eastern part of Lake St. Joseph.

Magnetite beds are interlayered with other sediments, but are much thinner and leaner than are the beds of the western part of the lake. Most of them are only a few inches in thickness, but zones occur several feet in width in which one-half of the rock consists of magnetite. The rocks commonly interbanded with magnetite are garnet gneiss, and staurolite schist. At the north side of Island 856, the rock immediately north of the iron formation is dark in colour and weathers to a nodular surface. In the field, it had the appearance of an igneous rock. Microscopic examination shows that the chief minerals are quartz, and fresh-looking green hornblende. The quartz individuals form a closely interlocking mosaic, and it seems probable that the rock is really an abnormal sediment in which the basic material has re-crystallized into hornblende. The magnetite beds are the result of the re-crystallization of some original iron mineral associated with quartz or with some other mineral which has changed to quartz. Some samples of magnetite contain a few deep red garnets in perfectly formed crystals as large as small peas.

The magnetite-bearing beds along the base line are cut off, and bent sharply from their normal strike by granite intrusions. Pegmatite dikes in places cut directly through the magnetite beds. On Island 856 granite is in direct contact with a bed of magnetite, inclusions of which are contained in the igneous rock. Nevertheless, the granite appears quite fresh and unaffected right up the contact. The sediments are evidently older than this particular granite, and the drag-folding indicates a syncline to the north. This view is corroborated by the position of the granite, which probably came in from below.

Igneous Group

Greenstone.—Greenstone occurs along the shore of the Indian Reserve south of Osnaburgh House and on the islands in that vicinity. No ellipsoidal structure was observed, and the differentiation between basic lavas and sedimentary rocks made up of material formed by the breaking down of basic rocks is somewhat difficult. Owing to the disturbances caused by the igneous intrusions, the structure and succession are not easily determined, but there is some evidence, although not entirely conclusive, that the greenstone lies above the sediments.

Photograph by courtesy of the Air Board of Canada.

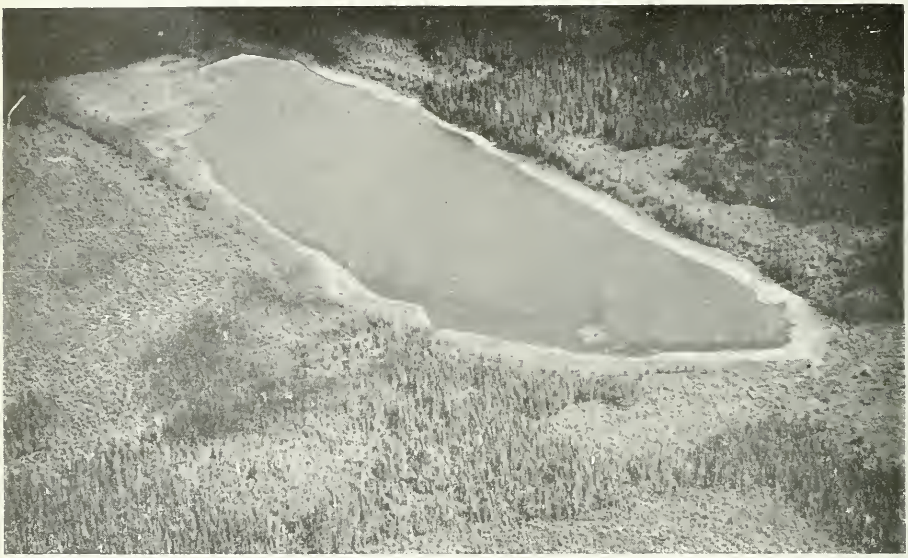


Fig. 2.—Lake in terminal moraine deposits, south of Lake St. Joseph. The photograph was taken on Sept. 15, 1921, from a height of 2,700 feet.

Granite and Other Intrusives

The intrusive rocks may belong to several different ages. Lamprophyre dikes cut the sediments, and holo-crystalline dioritic rocks are thought to be intrusive, although they have not been found in direct contact with other rocks. Granite and the pegmatite dikes associated with it are the most important intrusive rocks.

The lamprophyre dikes are similar in all respects to those described in the western section, and nothing need be added to that description. Such dikes were found cutting quartzite in outcrops in the marsh south of the bay which is crossed by the base line between Mile 10 and Mile 12. Diorite occurs on Island 648, on Island 709, and on several smaller islands near it. It is a completely crystallized rock of granitic texture, and may be related to the granite intrusion either as a differentiate from it or as a hybrid rock formed by the assimilation of basic material in the granite magma.

The granite is similar to that described in the previous report, but in this eastern section along many of the contacts there has been much more assimilation of the intruded rocks, and hence there are broad belts of hybrid rocks which differ from typical granite and vary in character from place to place. These have been included with the granite, although at many localities if each outcrop were considered by itself the rock could hardly be termed granite. This is especially true of the outcrops occurring on Carling island. Pegmatite dikes do not appear to be so numerous as they are in the western section, but this may be due to the fact that the amount of solid rock exposed is much less. The dikes are similar to those previously described.

Photograph by courtesy of the Air Board of Canada.

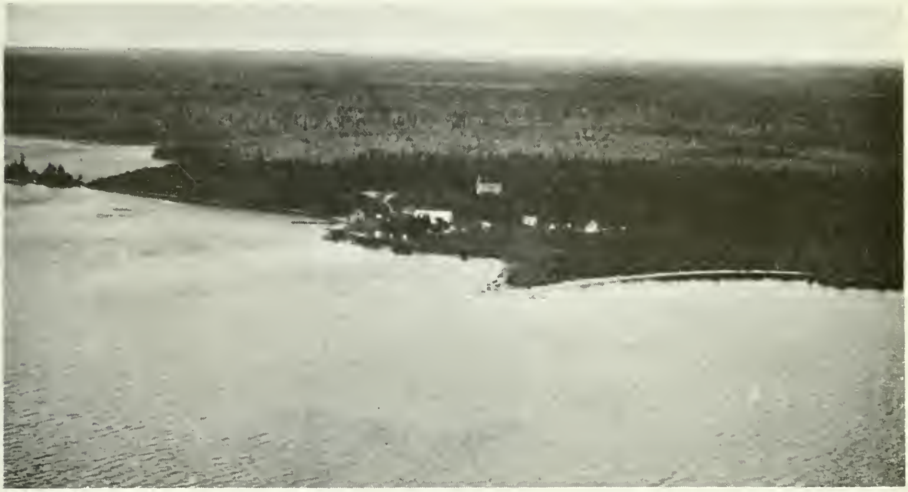


Fig. 3.—Osnaburgh House, Lake St. Joseph, viewed from an elevation of 800 feet. The H. B. Co. post is built on a hill of glacial sand with a sand pit in front of it.

Pleistocene Deposits

Deposits formed during the glacial period are thick and wide spread. Banks of sand and gravel cover all the solid rock over much of the area. Most of the deposit is typical terminal moraine, with hummocky and irregular hills, elongated knolls and winding esker-like ridges. Southeast of the lake and from Mile 22, eastward on the base line, the glacial deposits are thick and continuous, and as the forest has been almost completely burned away, the irregular hills and ridges of unsorted sand and gravel, among which lie lakes with no visible outlets, can be seen extending for a long distance to the south. Another great area of glacial deposits lies between the lake and the base line west of Mile 20. Forest cover obscures some of the details, but the oval lakes with no rock exposures can be recognized, Fig. 2.

Recent

At present, peat is forming in some of the undrained areas, and the glacial sands and gravels are being rearranged by the lake currents into new shore deposits. The abundant supply of sand has made possible some splendidly developed sand bars and sand spits, Fig. 3.

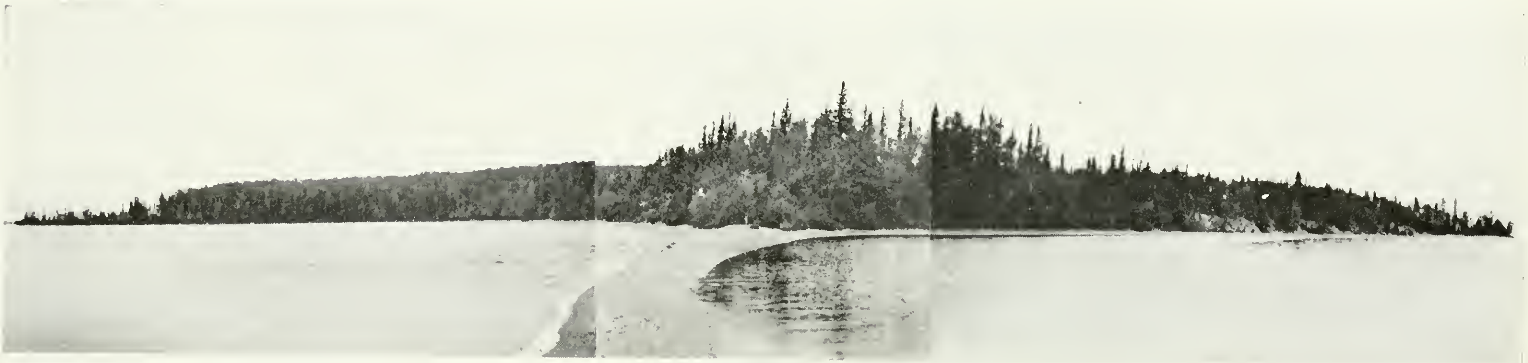


Fig. 4.—Island 670, Lake St. Joseph, showing sand spit formed on the south side.

AREA SOUTH OF THE WEST END OF LAKE ST. JOSEPH

By E. L. Bruce

Introduction

A lake of considerable size was reported to lie in the unmapped area south of Lake St. Joseph and west of the primary meridian. An exploration was decided upon to determine the location and size of the lake and, if possible, to obtain additional information with regard to the character and structure of the sedimentary gneisses that occur along the south shore of Lake St. Joseph. A sketch furnished by J. S. Dobie, was found to agree fairly closely with the position of the lake. The name Shekak is suggested for this body of water, as it is said that a man named Skunk formerly trapped in that section.

The lake is reached by ascending a fair-sized stream that enters the large bay extending southwestward from the main channel of Lake St. Joseph, three miles east of the primary meridian. A rapid occurs at the mouth of this stream but this can be easily ascended by poling. Half a mile above the rapid a tributary enters from the west. This drains two small lakes, the upper of which is crossed by the meridian at Mile 57. Half-a-mile west of the meridian a stream enters the lake with a heavy rapid at the mouth. This was ascended by tracking, but there is an old portage eleven chains in length on the right bank. The lower end of the portage is a little distance south of the mouth of the stream. Shikkagami lake is directly above the rapids.

The lower part of the lake extends westward for four miles to a large island which blocks the passage, leaving only a narrow channel on either side. From this island the lake extends in many long bays to the southwest. The most southerly bay reaches a point ten miles southwest of the narrows, and so the lake has a total length of about fourteen miles. The greatest width is three miles. The track survey by canoe was supplemented by a flight over the lake by seaplane; this made possible some corrections in outline and the recognition of connecting lakes, which drain into the southeast bay and may form a canoe route for some distance southward.

The waters of Shekak lake are fairly clear with a slightly brownish colour, but not the dark brown of the water in many lakes near the head of river systems in pre-Cambrian regions. This is due to the comparatively small proportion of swampy country in its drainage basin, for much of the district is covered by the sandy glacial deposits of the terminal moraine extending southwestward from Lake St. Joseph. The irregular ridges and knolls of glacial sand and gravel can be well seen on large islands in the central part of the lake, where the forest fires have removed the timber. Much of the mainland of this part is wooded, but the long, smooth, pebble beaches are typical of the drift-covered area. The southwestern end is beyond the margin of the moraine and lies in a rugged country with high, bald ridges and knolls of granite.

Geology

Outcrops are fairly numerous at the lower and upper ends of the lake, but the central part has boulder and sand beaches with few exposures of solid rock. The stream draining the lake, and a small part of the lower end of the lake, lie in an area of granite continuous with the granite area found along the base line south of Lake St. Joseph. The rock of the central part of Shekak lake is brown-weathering mica gneiss, with little variation except that produced by the metamorphic effect of granite intrusions. Toward the south, where the second great belt of granite appears, the gneisses are very severely altered. They are thoroughly impregnated with material from the intrusive and, in many places, it is difficult to draw any satisfactory line between the two rocks. The gneiss is undoubtedly of sedimentary origin. The distinctly bedded character and the highly quartzose composition are conclusive evidence of this. As in the gneisses of Lake St. Joseph, it is rather difficult to account for this thick series of sedimentary beds so homogeneous in nature, apparently clastic, but with no conglomeratic beds whatever.

The intrusion of the granite has taken place largely *lit-par-lit* and in many places the original bedded structure is retained, although the material of the rock is now more largely igneous than sedimentary. This type of intrusion adds considerably to the difficulty of satisfactory mapping, as granite and gneiss interfinger most intimately along the contact. The gneisses are also intruded by large pegmatites, many of which have come in along the bedding, and as they form ridges, an erroneous opinion of the relative importance of gneiss and pegmatite may be formed. In some cases what appear to be ridges of solid pegmatite are found on closer observation to be gneiss, faced with pegmatite.

The structure of the gneiss at the lower end of the lake is well shown. Where first observed the dip is steep to the northward and the strike nearly east and west. To the south, the strike swings to the northwestward and the dips flatten to 45° to the northeast. Still farther south the strike is north and south, and the dip 15° to the east. Continuing southward, the strike is northeast-southwest with dips to the southeast and then swings east and west again with steep dips to the south. It is evident that the structure is a closely appressed anticline which plunges to the east at an angle of 15°. The dips farther south give some evidence of a minor syncline, the axis of which is only a short distance south of this main anticlinal axis. There may be a second anticlinal axis towards the south end of the lake, but the disturbance introduced by granite intrusions makes the evidence less clear. The relation of this structure to that of the gneiss along Lake St. Joseph is not determinable. It is believed from evidence given in detail in a previous report that the Lake St. Joseph occurences are on the northern limb of an anticline. If it be assumed that the Shekak Lake anticline is the first anticline south of Lake St. Joseph, and that it occupies its original position, the thickness of sediments is enormous. It seems more reasonable to assume that there are some intermediate folds now completely destroyed by the granite intrusion. It is also possible that there has been a fault zone along which the granite has come in. In that case the anticlinal crest exposed on Shikkagami lake may be down-faulted part of beds originally lying much farther north. So far as the problem of the structure of the Lake St. Joseph beds is concerned, the evidence is at least corroborative of the eastward plunge of the axes of the folds.

No evidence of any mineralization of possible importance was observed in any of the exposures seen along the lake shores.

INDEX

Vol. XXXI., Part VIII.

Page

- Agriculture.
  - St. Joseph l. 6
- Analyses, iron ores 30, 31
- Andesite 2
- Anticline 13, 40
- Archean shield. *See* Pre-Cambrian.
- Arkose.
  - St. Joseph l. 7, 34
    - description 9
    - petrography 25
- Assays.
  - Quartz, L. St. Joseph 32

- Batholiths 2
- Bell, Dr. Robt. 2, 23
- Biotite-garnet gneiss.
  - L. St. Joseph 7, 34
- Biotite gneiss 7
- Blackstone l.
  - Boulders 21
    - photo 20
  - Rocks 4, 17
- Boulders, glacial.
  - Blackstone l., notes and photo 20, 21
- Bruce, E.L.
  - Reports by, on St. Joseph l. 1-40

- Camsell, Charles 2
- Canadian shield. *See* Pre-Cambrian.
- Carling island 37
- Carter, Capt. A. W. 1
- Chemical precipitation.
  - As origin of iron deposits 27
- Chlorite schist, St. Joseph l. 7, 23, 34
  - description 16
- Clastic sedimentation.
  - As origin of magnetite deposits 26
- Clinton iron ores 27, 28
- Comer, J. F. 1
- Concentration of iron ore.
  - St. Joseph l., ratio 31
- Conglomerate.
  - St. Joseph l. 34
    - magnetite nodules in, photo 10
- Contact metamorphism.
  - As origin of magnetite deposits 26
- Couchiching series 13

- Davison, John E. 2
- Diamond-drilling.
  - Iron, St. Joseph l. 24
- Diorite.
  - St. Joseph l. 7, 16, 17, 36
- Dobie, James E. 1, 2, 33, 39

- Farming. *See* Agriculture.
- Fawcett, Thomas 2
- Fish.
  - St. Joseph l. 3, 6
- Forests. *See* Trees.
- Formations. *See* Table of formations.
- Fraser, G. L. 1
- Fur-bearing animals.
  - St. Joseph l. 3

- Garnets.
  - St. Joseph l., in magnetite 25, 27
- Geology, economic
  - *See* Granite; Iron; Gold.
- Geology, general
  - St. Joseph l. 7-22
    - eastern 33-37
    - western 39, 40
- Glaciation.
  - St. Joseph l., notes 21, 37
- Gneiss.
  - L. St. Joseph 4, 7, 8
    - structure 40
- Gold.
  - St. Joseph l., possibility 3
- Graham, S. N. 31
- Granite.
  - *See also*. Binary granite.
  - L. St. Joseph 2, 4, 7
    - notes 19, 20, 26, 36
- Granite porphyry.
  - St. Joseph l. 7, 19
- Gravels, glacial
  - St. Joseph l., photo 4
- Greenalite.
  - L. Superior iron deposits 27
- Greenstone.
  - L. St. Joseph 7, 34
    - description 36
    - intruded by granite 20
    - prospecting advisable 32
- Greig, J. W. 1, 16
- Greywacké.
  - L. St. Joseph 4, 7
    - description 9
    - petrography 25
  - Savant l. 29

- Hematite. *See also*. Iron-bearing beds.
  - L. Superior iron ores 28
  - St. Joseph l. 3
- Hints to prospectors.
  - Quartz veins, St. Joseph l. 32
- Hornblende schist.
  - St. Joseph l. 23

- Iron formation.
  - L. St. Joseph, Report by Bruce 1-32
    - eastern 33-36
    - mineralogy 24, 25
  - L. Superior, origin 27
  - Savant l. 13, 29
- Iron-bearing beds.
  - *See also* Iron formation.
  - L. St. Joseph, geology 10-13
- Island No. 6 19
- Island No. 10 19
- Island No. 17 31
- Island No. 34 32

PAGE

- Island No. 84.
  - Folding, photo 13
  - Magnetite 4, 23, 30, 31
  - Photo 24
  - Quartz, assay 32
  - Rocks 9, 25
- Islands Nos. 103 and 104 15
- Islands Nos. 119 and 123 15, 17
- Island No. 131.
  - Magnetite, analysis 30
- Island No. 133 25
- Island No. 158 25
- Island No. 162.
  - Magnetite 30, 31
- Island No. 184.
  - Folding, photo 13
- Island No. 185 9
- Islands Nos. 212 and 250 15
- Island No. 276 17
- Island No. 337 8
- Island No. 353 8
- Island No. 400 14, 16
- Island No. 407 9
- Island No. 648 36
- Island No. 670
  - Sand spit, photo 38
- Island No. 709 36
- Island No. 856 35

- Jackpine.
  - St Joseph l 6
- Jasper.
  - Iron formation 27
  - Savant l 29

- Lake No. 1.
  - Glacial drift near, photo 4
- Lake No. 2, granite 19
  - Prospecting advisable 32
- Lake Superior
  - Iron ore, alteration 31
    - origin 27, 28
- Lamprophyre dikes 2, 16, 17, 22
- Laurentian shield. *See* Pre-Cambrian.
- Lava.
  - St. Joseph l., notes 16, 17, 22
- Lawson, A. C. 13

- McInnes, William 2
- Magnetic variation
  - St. Joseph l 23, 31
- Magnetite.
  - *See also* Iron-bearing beds.
  - St. Joseph l., notes and photo 3, 10, 30
    - Island No. 84 4
- Manitou rapids 2
- Mica gneiss, L. St. Joseph 34
  - Shekak l 40
- Mile No. 10 35
- Mile No. 12 35
- Mile No. 14 35
- Mile No. 18 34
- Mile No. 20 34, 35
- Mile No. 22 34
- Mineralogy, iron formation 24, 25
- Moore, E. S. 29
- Moraines, terminal
  - L. St. Joseph 2
    - photos 5, 38

PAGE

- Murray, G. B. 1

- Osnaburgh House.
  - Agriculture 6
  - Rocks near; photo 36, 37

- Paragneiss 7, 8
- Parsons, A. L. 2
- Patrician glacier 5
- Peat bogs 21, 37
- Pegmatite.
  - L. St. Joseph 2, 4, 34
    - age 22
    - description 20
    - intruding gneisses 40
- Petrographic notes.
  - Gneiss, L. St. Joseph 8
  - Iron formation 25
- Photomicrographs.
  - Quartz porphyry 14, 18
  - Quartzite 35
- *Picea* 19
- Pickerel
  - L. St. Joseph 6
- Pike, L. St. Joseph 6
- Pleistocene 21, 37
  - *See also*, Glaciation.
- Poplar 6
- Porphyry. *See* Granite porphyry.
- Pre-Cambrian.
  - L. St. Joseph area 2, 34
- Pre-granite complex.
  - L. St. Joseph area 7-19, 34, 35
- Prospecting.
  - *See also* Hints to prospectors.
  - L. St. Joseph, historical notes 23
- Pulpwood 6, 33
- Pyroclastics 7, 16, 17
  - photo 18

- Quartz-hornblende gneiss 7, 9
- Quartz porphyry.
  - St. Joseph l 2, 7, 10
    - age 19
    - photomicrograph 13-18
- Quartz veins.
  - L. St. Joseph, non-auriferous 3, 32
- Quartzite.
  - L. St. Joseph 7, 9, 34
    - cut by dikes 36
    - description 10
    - photomicrograph 35
    - structure 4

- Recent deposits.
  - L. St. Joseph area 21, 37
- Rhyolite 16
- Rock structure.
  - St. Joseph l., relation to topography 4
- Root river 2, 6

- St. Joseph lake.
  - Reports on, by Bruce 1-40
- Sand, glacial
  - St. Joseph l., notes and photos 3, 4, 37
- Sand bars or spits.
  - St. Joseph l., notes and photos 5, 21, 37, 38

PAGE

Sand pit.
  Osnaburgh House, photo........... 37
Savant lake.
  Iron ore, description............13, 29
  Rocks 16
Sea water.
  Hematite in, as origin of iron ores 28
Sedimentary group.
  L. St. Joseph area..........7-19, 34, 35
Sedimentation.
  See also Clastic sedimentation.
Sericite schist 7, 10
Shekak lake 6, 13, 39, 40
Silver.
  St. Joseph l., in quartz............ 32
Sioux Lookout..................... 2
Skunk l. *See* Shekak l.
Soil. *See* Agriculture.
Spits. *See* Sand bars.
Spruce 6
Station No. 13...................... 9
Station No. 136..................... 9
Station No. 146..................... 9

PAGE

Station No. 207..................... 8
Staurolite schist..................34, 35
Striæ, glacial
  L. St. Joseph...................... 21
Syncline
  L. St. Joseph, iron ore possible in. 31

Table of formations. L. St. Joseph 7, 34
Topography
  L. St. Joseph area.................3-6
Trees
  L. St. Joseph, area..............6, 33

Volcanic group
  St. Joseph l., area................7-19

Waterpower
  L. St. Joseph...................... 3
Whitefish 6
Williams, Jabez..................... 24
Williams, L. F...................... 1
Williams, L. G...................... 1
Wilson, A. W. G..................... 2
Wright, David....................... 1

PROVINCE OF ONTARIO
DEPARTMENT OF MINES

HON. H. MILLS, MINISTER OF MINES THOS. W. GIBSON, DEPUTY MINISTER

THIRTY-FIRST ANNUAL REPORT
OF THE
ONTARIO DEPARTMENT OF MINES
BEING
VOL. XXXI, PART IX, 1922

The Stratigraphy and Paleontology
OF
Toronto and Vicinity

PART III.—GASTROPODA, CEPHALOPODA, and VERMES

By
W. A. Parks, Ph.D. assisted by Madeleine Fritz, B.A.

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY OF ONTARIO

TORONTO
Printed by CLARKSON W. JAMES, Printer to the King's Most Excellent Majesty
1923

Printed by
THE RYERSON PRESS

THE STRATIGRAPHY AND PALEONTOLOGY
OF
TORONTO AND VICINITY

Part III.—Gastropoda, Cephalopoda, and Vermes

By

W. A. Parks, assisted by Madeleine Fritz

Introductory

Two parts of this series have already appeared in the Reports of the Ontario Department of Mines: they deal with the Pelecypoda[1] and Molluscoidea[2] occurring in the rocks at Toronto.

The present part treats similarly of the classes Gastropoda, Cephalopoda, and Vermes.

The series of articles of which this is the third number was undertaken in order to furnish a full and modern account of the fossils occurring in the rocks at Toronto. As the original illustrations of most of the species are contained in literature difficult of access, it has been decided to introduce a figure of each species referred to.

In the two parts already published, as also, in the present part the fossils are described without particular reference to their range as it is the intention to fully consider this aspect of the subject in Part IV, to be published at a later date. It will deal with the remaining groups of fossils and with the stratigraphy and correlation of the local formations at Toronto.

The *Gastropoda* of the Toronto rocks are very badly preserved; in consequence, great difficulty attends some of the identifications. We recognize ten described species to which we have added one new variety and one doubtful species, too uncertain to be definitely named.

The *Cephalopoda* show five species; of these *Actinoceras crebriseptum* is so abundant and so unique that considerable space has been devoted to a description of the detail of its structure.

The *Vermes* are represented by one tubicolar annelid and thirty-four errant types of which only the jaws are known. We have been able to add nothing to Hinde's excellent account of these minute structures: his descriptions and figures are reproduced without change. It has been thought advisable to include the five *conodonts* (teeth of *cyclostomes* ?) described by Hinde.

A single species of *Conularia* is included.

The figures accompanying Part III have been prepared partly by ourselves and partly by Miss Emily Logier. In a few cases it has been found necessary to reproduce figures already published.

---

[1] Ont. Dept. Mines Report, Vol. XXIX, Part VI, 1920.

[2] Ibid, Vol. XXX, Part VII, 1921.

Description of Species

The species herein described belong to the two great phyla: *Mollusca* and *Vermes.* Of the former, the two classes considered are the *Gastropoda* and the *Cephalopoda.* Without further introduction these two classes will be first dealt with.

GASTROPODA

Order ASPIDOBRANCHIA

Family ACMEIDAE

Genus ARCHINACELLA, *Ulrich and Scofield*

ARCHINACELLA, *Ulrich and Scofield.* Geol. Minnesota 3, pt. 2, 1897, pp. 821-828.
ARCHINACELLA, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 61.

The small shells now placed under this genus have been variously ascribed to *Metoptoma, Triblidium,* and other genera. *Archinacella* is defined as follows by Ulrich and Scofield:

> Shell patelliform, ovate to subcircular, usually widest anteriorly, forming a low cone with the apex in front of the center and often submarginal. Muscular scars forming a continuous band. Surface markings concentric only.

ARCHINACELLA PULASKIENSIS, *Foerste*

Plate 1, Figures 1 and 2.

CARINAROPSIS PATELLIFORMIS, *Hall.* Pal. New York, 1, 1857, p. 306, pl. 83, figs. 7a-b.
ARCHINACELLA PULASKIENSIS, *Foerste.* Bull. Sci. Lab. Denison Univ., 17, 1914, p. 309. pl. 3, figs. 3a-d.
ARCHINACELLA PULASKIENSIS, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p.64.

The true *Archinacella patelliformis* of Hall is defined as follows:

> Obliquely subconical, patelliform, the apex incurved and extended in a line with or beyond the margin, obtusely carinated upon the dorsal line; aperture broadly oval, slightly narrowed posteriorly; surface marked by fine concentric sublamelliform striae.
>
> This species resembles in form the recent *Capulus;* but the structure of the shell is quite different, being, in this respect, closely allied to the *Bellerophon.* There are one or two other species in the Hudson River group, and a single more elevated one in the Trenton limestone, which has not been satisfactorily determined.

Hall himself ascribed to the same species certain specimens from the Hudson River group at Pulaski and elsewhere. Foerste (*op. cit.*) has pointed out that the Trenton and the Hudson River types of Hall are different and has proposed the name *A. pulaskiensis* for the latter. His comments on the two species are as follows:

> The form figured by Hall from the Lorraine at Pulaski, New York, as *Archinacella patelliformis,* differs in outline from his Trenton types, which were derived from the dark, compact, Trenton limestone at Middleville, New York. This shell is broader and more convex along the middle and the outline, therefore, is rather broadly ovate than ovate oblong. Otherwise the two shells are closely similar. The beak extends almost or fully as far forward as the anterior margin of the shell. It overhangs this margin by an anterior slope which on lateral view is not so strongly concave. The beak is rather pointed, especially when viewed from above, and there is a tendency toward carination for a moderate distance posterior to the beak. The highest part of the shell is about five-twelfths of the length of the shell from the anterior margin. The shell is smooth, surface striations being faint or absent.
>
> The type of the species occurs in the same rock with *Modiolopsis modiolaris, Byssonychia radiata, Hormotoma gracilis, Dalmanella,* and *Glyptocrinus* columnals.
>
> This species occurs at the *Trinucleus* horizon, several hundred yards west of the railroad bridge across the river, east of Pulaski. It is found also northeast of the bridge within the limits of Lorraine village, and along the creek within the boundaries of Barnes Corners. It is found also at the power house at Bennett Bridge, a little over a mile west of the Salmon River falls.

The same species occurs in the province of Quebec, on the Richelieu river at Chambly. A similar form is found on the Nicolet river, southwest of Ste. Monique, about 575 feet below the lowest horizon containing *Strophomena planumbona.*

This type of gastropod is quite common at Toronto and approaches more closely *A. pulaskiensis.* The specimen drawn is a cast of the interior, but it shows well the ovate outline characteristic of the species and also the continuous muscle band which Ulrich considers characteristic of the genus. The length is 16 mm. and the width is 13.5 mm. Considerable variation in size is observed, some specimens being as much as 26 mm. long. Variations are also observed in the degree to which the ridge posterior to the apex is developed, some specimens being quite rounded.

Locality.—Don brickyard, Toronto.
No. 1211 H.R. Royal Ontario Museum of Paleontology.

Family CYRTOLITIDAE

Genus CYRTOLITES, *Conrad*

CYRTOLITES. *Conrad.* Ann. Rep. Nat. Hist. Surv. New York, 1838, p. 118.
CYRTOLITES. *Ulrich and Scofield.* Geol. Minnesota, 3, pt. 2, 1897, pp. 846-858.
CYRTOLITES, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, pp. 365, 366. (See for full bibliography).

Ulrich and Scofield describe the genus as follows:

Shell coiled in the same plane, symmetrically or nearly so; volutions two or three, scarcely contiguous, the last occasionally free, enlarging gradually, carinated on the back and often on the sides, giving a subquadrate cross-section; aperture not abruptly expanding, with or without a median notch in the outer lip; no slit-band; shell thin, without callosities of any kind; surface sculpture reticulated or cancellated, consisting of straight or obliquely curved regular transverse lines connected by short oblique lines.

CYRTOLITES ORNATUS, *Conrad*

Plate 1, Figures 3, 4 and 5.

CYRTOLITES ORNATUS. *Hall.* Pal. New York, 1, 1847, p. 308, pl. 84, figs. 1a-g.
CYRTOLITES ORNATUS. *Chapman.* Canadian Jour., new ser., 7, 1862, p. 119, fig. 119; 8, 1863, p. 206, fig. 207.
CYRTOLITES ORNATUS, *Billings.* Geol. Canada, Geol. Surv. Canada, 1863, p. 217, fig. 226.
CYRTOLITES ORNATUS. *Meek.* Pal. Ohio, 1, 1873, p. 148, pl. 13, figs. 3a-b.
CYRTOLITES ORNATUS. *Ulrich and Scofield.* Geol. Minnesota, 3, pt. 2, 1897, p. 860, pl. 62, figs. 27-29.
CYRTOLITES ORNATUS. *Cumings.* 32nd Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1908, p. 962, pl. 40, figs. 8, 8a.
CYRTOLITES ORNATUS, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 367.
CYRTOLITES ORNATUS, *Foerste.* Geol. Surv. Canada, Mem. 83, 1916, pp. 85, 90.

Cyrtolites ornatus is one of the most common gastropods found in the Toronto vicinity. Although the species occurs in abundance, well-preserved examples are rare, as most specimens are much flattened and distorted.

A description by Ulrich and Scofield follows:

Shell varying in diameter between 12 mm. and 30 mm., with the average at about 23 mm. Volutions two or three, rapidly increasing in size, strongly and sharply carinate dorsally, rhombic subquadrate in section; sides prominent and subangular or narrowly rounded along a line about three-fifths of the hight of the volution within the dorsal carina, the dorsal slopes gently convex and distinctly undulated by strong slightly curved transverse furrows and subangular ridges, the ventral or umbilical slopes almost flat and usually without undulations; ventral side with a sharp central furrow for the reception of the dorsal carina of the preceding volution. Umbilicus well defined, wide and deep, the edge wavy. Aperture a little wider than high, the hight equalling usually a trifle more than half the greatest diameter of the shell, more or less rhombic-subquadrate, the outline often becoming a little rounded with age. Entire surface covered by a delicate network formed of raised lines running almost straight across the whorls and short connecting lines arranged alternately, the result being somewhat similar to the pitting of a thimble. In a good light the network is generally distinguishable without the aid of a magnifier, and, excepting three specimens, quite uniform in strength in different shells, there being on the outer half of the last whorl nearly always seven or eight of the transverse lines and eight or nine of the short lines in 2 mm. In the excepted specimens the network is more compact, there being over the outer part of the last whorl from ten to twelve of the transverse lines in the same space. On another, with the reticulation unusually coarse, the number averages between six or seven. On the last specimen a good magnifier brings out some very fine lines of growth running through the network. It is important to note that there is no perceptible backward curvature of the transverse lines in nearing and crossing the dorsal carina.

The Toronto specimens seem to conform very closely with the figures and descriptions of this species already published. Owing to imperfections, the characteristic features of the apertural region cannot be verified. A degree of variation is observed in our specimens, but it is frequently impossible to determine whether these are inherent or due to crushing. For instance, the lateral angulation is in some cases much sharper than is indicated in published figures of the species, but it is quite possible that this is the result of pressure. The keel on the periphery, in some cases, is quite well defined, but in our best specimens it is merely a sharp angularity with but a slight concavity on either side. In these cases the finer surface ornamentation is quite uninterrupted across the keel. The chief direction in which variation occurs is in the number and strength of the transverse furrows and ridges; in some cases these are so sharply defined and prominent as to catch the eye at once, in other cases they are quite low and might almost be overlooked by the naked eye. In many specimens the ridges near the aperture are as much as 5 mm. apart, but in extreme cases the interval does not exceed 2 mm. The finer transverse ridges are likewise variable in distance, from two to four appearing in an interval of 1 mm. at approximately the same location on the shell of different individuals.

Our collection does not afford a specimen of sufficient perfection to furnish a better illustration than many of the published figures. The figures have been copied from Ulrich and Scofield with some slight changes. Figures 3 and 4 are from our specimen.

Locality.—6-foot level, Humbervale Quarry, Don brickyard.
Nos. 1208, 1209 H.R., Royal Ontario Museum of Paleontology.

Family SINUITIDAE

Genus SINUITES, *Koken*

SINUITES. *Koken.* Die Leitfossilien, Leipzig, 1896, p. 392.
PROTOWARTHIA. *Ulrich and Scofield.* Minnesota Geol. 3, 1897, pp. 848, 867.
BELLEROPHON, *Montfort.* Conchiliologie Systematique, 1, 1801, p. 51.
BELLEROPHON (part), *Auctores.*

The genus *Bellerophon* in the usage of many authors includes diverse types of thin-shelled, convolute gastropods with a central emargination of the outer lip, a well developed slit band, and with the volutions more or less rounded on the back. The genus *Protowarthia* was proposed by Ulrich for shells of this general type characterized as follows:

> Aperture large but not abruptly expanded, the outer lip bilobate, with a broad and more or less deep sinus but neither a slit nor band; dorsum convex, never carinate; umbilicus closed; surface markings very fine, generally consisting of more or less obscure crowded lines of growth and delicate revolving striae. The inner lip forms a thin granulose deposit over the dorsum of the inner end of the last whorl and extends on each side around the umbilical region. This portion is covered with interrupted or inosculating lines.

Ulrich's description appeared in 1897, but Koken had proposed *Sinuites* for shells of the same type a year earlier; thus the genus *Sinuites* has priority.

SINUITES CANCELLATUS, (*Hall*)

Plate 1, Figures 6, 7, 8.

BELLEROPHON BILOBATUS (*not Sowerby*), *Auctores.*
BELLEROPHON CANCELLATUS, *Hall.* Pal. New York, 1, 1847, p. 307, pl. 83, figs. 10a-c.
PROTOWARTHIA CANCELLATA, *Ulrich and Scofield.* Geol. Minnesota, 3, pt. 2, 1897, p. 872, pl. 63, figs. 1-14.
SINUITES CANCELLATUS, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 1159 (See for extended synonymy).

Examples of this species are fairly abundant in the Toronto rocks, but they are all very imperfectly preserved.

Hall's original description of the species follows:

> Involute, subglobose; aperture expanded, bilobate; dorsal line subcarinated; surface cancellated by fine concentric and longitudinal striae; concentric striae arching on the side, and meeting at a sharp angle upon the dorsal line; aperture with a sinus in the dorsal margin.

Although this species is abundant, we have found no specimen with shell preserved nor any which are not seriously deformed. In consequence, the figures given herewith have been copied from Ulrich and Scofield (*op. cit.*).

Family PLEURОTOMARIIDAE

Genus CLATHROSPIRA, *Ulrich and Scofield*

PLEUROTOMARIA (part), *Auctores.*
CLATHROSPIRA, *Ulrich and Scofield.* Geol. Minnesota, 3, pt. 2, 1897, pp. 954-1005.
CLATHROSPIRA, *Cumings.* 32nd. Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1908, p. 948.
CLATHROSPIRA, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 228 (See for full bibliography).

The genus *Clathrospira* was established by Ulrich and Scofield (*op. cit.*) for the reception of those forms otherwise like *Eotomaria* but with the band nearly vertical and situated upon the periphery of the whorls, and with the surface beautifully cancellated.

The description of *Eotomaria* follows:

> Shell depressed-conical, sometimes sublenticular; base more or less convex, its bulk usually nearly equal to the apical part; umbilicus very small or wanting; volutions not very numerous, sometimes slightly turriculate or strongly angular near the mid-hight; aperture oblique; subquadrate, the inner lip slightly reflected or merely thickened, the outer deeply notched at the peripheral angle; no slit; band of moderate width, concave, sharply defined, oblique or horizontal, lying upon the apical side of the periphery. The surface markings consist of fine lines of growth only. These curve backward more or less strongly toward the band on both the upper and lower sides of the whorls.

CLATHROSPIRA SUBCONICA (*Hall*)

Plate 1, Figure 9.

PLEUROTOMARIA SUBCONICA, *Hall.* Pal. New York, 1, 1847, p. 174, pl. 37, figs. 8a-e; p. 304, pl. 83, figs. 3a-e.
PLEUROTOMARIA SUBCONICA, *Billings.* Geol. Surv. Canada, 1863, p. 180, fig. 174.
CLATHROSPIRA SUBCONICA, *Ulrich and Scofield.* Geol. Minnesota, 3, pt. 2, 1897, p. 1006, pl. 69, figs. 47-50; pl. 70, figs. 5-6.
CLATHROSPIRA SUBCONICA, *Cumings.* 32nd. Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1908, p. 956, pl. 41, figs. 8, 8b.
CLATHROSPIRA SUBCONICA, *Foerste.* Geol. Surv. Canada, Memoir 83, 1916, p. 249. (See Bull. 92, U.S.N.M. for full synonymy).

The description of this species as given by Ulrich and Scofield follows:

Shell with a short conical spire, consisting, when fully grown, of six and a half or seven volutions, of which the two at the apex are usually broken away; greatest width and height nearly equal, varying generally between 25 and 30 mm., but attaining occasionally a width of over 40 mm.; apical angle 70° to 80°, but in four specimens out of every five the variation is only about one degree either way from 74°. Volutions flattened above in the direction of the slope of the spire, the inner half of the slope gently convex, the outer half correspondingly, or more strongly concave; convex portion of slope just touching or failing to reach a line drawn from periphery to periphery of succeeding whorls; under side of whorls rounded, occasionally very slightly concave near the periphery, this condition appearing, however, only in specimens in which the band is unusually prominent, umbilical depression small, terminating generally in a minute axial perforation. Band prominent, sharply defined, rather wide, concave, nearly vertical, situated on the periphery of the last volution, and lying immediately above the suture line on the upper whorls. Aperture subquadrate, outer lip broadly notched; columellar lip not very strong, thin, folding about the small umbilical perforation. Surface sculpture beautifully cancellated, consisting of two sets of fine, subequeal, thread-like lines, one revolving, the other running parallel with the margin of the aperture. The transverse lines, of which three to five occur in the space of 1 mm., are recurved as usual on the upper side and quite as much on the lower side. At intervals, sometimes quite regular, many specimens exhibit more or less distinct undulations of growth, in some examples little more than a millimeter apart, in others two, three, or four millimeters. Considerable variety as regards strength and arrangement of the lines forming the surface sculpture may be observed in specimens from different localities.

The occurrence of this species in our rocks is open to some question. In our collections we have only three or four small specimens, very imperfect, but which seem to show the general form of this species. In addition, we have a portion of an impression or external mould of a much larger example which conforms very closely to *Clathrospira subconica.* The specimen figured herewith was obtained from the vicinity of Toronto, but the character of the rock indicates, with reasonable certainty, that it has been derived from Trenton drift. The fine revolving lines, mentioned in the description, are scarcely discernible, but the transverse lines are very sharply defined. The umbilical portion has been copied from Ulrich and Scofield.

Locality.—Trenton drift, Toronto.
No. 292 T., Royal Ontario Museum of Paleontology.

Genus HORMOTOMA, *Salter*

MURCHISONIA (part), *Auctores.*
HORMOTOMA (subgenus of Murchisonia), *Salter.* Geol. Surv. Canada, Can. Org. Remains, dec. 1, 1859, pp. 18, 22.
HORMOTOMA, *Ulrich and Scofield.* Geol. Minn., 3, pt. 2, 1897, pp. 959, 1012.
HORMOTOMA, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 643. (See for full bibliography).

Ulrich and Scofield describe the genus as follows:

Shell elongate, beaded, practically imperforate, composed of rather numerous (eight to fourteen) rounded or subangular whorls; aperture acuminate subovate, narrow and more or less prolonged below; outer lip with a broad and deep v-shaped notch and no slit; band median or submedian, generally obscure, of moderate width, flat or slightly concave, in the perfect condition margined on each side by a delicate raised line; surface marked with lines of growth only; these are never very sharp and always sweep backward very strongly, from below especially, to the band.

HORMOTOMA GRACILIS (*Hall*)

Plate 1, Figure 10.

MURCHISONIA GRACILIS, *Hall.* Pal. New York, 1, 1847, p. 181, pl. 39, figs. 4a-c.
HORMOTOMA GRACILIS, *Ulrich and Scofield.* Geol. Minn., 3, pt. 2, 1897, p. 1015, pl. 70, figs. 18-21, ? 22.
HORMOTOMA GRACILIS, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 645. (See for full bibliography).

The description by Ulrich and Scofield follows:

Hight 20 to 33 mm., apical angle very constantly about 18°. Shell small, slender; volutions about fourteen in a length of 30 mm.; rounded, generally with a slight angulation, on which lies the band, a little beneath the middle; band seldom preserved, when perfect, rather narrow, smooth, flat or faintly concave and margined on each side by a delicate raised line; suture simple, deep; lines of growth fine, bending strongly backward from the suture to the band, and beneath this curving very strongly forward again, the whole indicating a deeply notched mouth; aperture a little higher than wide, rounded except below where it is somewhat produced; inner lip reflected, forming a slightly twisted and thickened columella.

This species has been recorded from the rocks at Toronto by Nicholson and others; it is said to be abundant "in the Hudson River group, Lake shore, Toronto." The old collections of the museum and all the material hitherto obtained for the preparation of this report contain only two small internal casts which can reasonably be ascribed to this species: these were collected from the quarry on the Don by J. Townsend. These specimens are each about 12 mm. long showing four whorls only; both the apex and the umbilical portions are broken and lacking. Apical angle about 18°.

The species is subject to much variation and ranges from the Trenton to the Richmond. The type was described from the Trenton and varieties from as high as the Richmond. Our form approaches more closely to the type than to any of the described varieties but differs somewhat in having greater inclination of the sutures. The total number of whorls and the maximum size cannot be ascertained as we have no specimen sufficiently perfect.

The figure given herewith is prepared from these specimens with additions from published figures.

Locality.—Don brickyard, Toronto.
No. 1213 H.R., Royal Ontario Museum.

Genus LIOSPIRA, *Ulrich and Scofield*

Pleurotomaria and Raphistoma (part), *Auctores.*
Liospira, *Ulrich and Scofield.* Geol. Minnesota, 3, pt. 2, 1897, p. 953.
Liospira, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 745. (See for full bibliography).

Ulrich and Scofield describe the genus as follows:

Shell sublenticular, the spire low, depressed conical, almost smooth, the sutures very close, scarcely distinguishable; volutions subrhomboidal in section, flat, gently convex or slightly concave above, sharply rounded at the periphery, convex below, and not infrequently angular at the edge of the umbilicus. The latter is usually present but may be filled entirely by an extension from the inner lip, in other cases it may be open during the younger stages only. Aperture deeply notched; band scarcely distinguishable as such, wide, situated on the narrow outer edge of the whorls though chiefly upon the upper side. Surface markings very delicate, rarely preserved, consisting generally of exceedingly fine transverse lines bending strongly backward on the apical side to the peripheral band over which they continue with little interruption to sweep sharply forward again on the lower side. Faint revolving lines occasionally observed.

Liospira helena (*Billings*)

Plate 1, Figures 11 and 12.

Pleurotomaria helena, *Billings.* Can. Nat. Geol., 5, 1860, p. 165, fig. 8; Cat. Sil. Foss. Anticosti, Geol, Surv. Canada, 1866, p. 17.
Liospira helena, *Ulrich and Scofield.* Geol. Minnesota, 3, pt. 2, 1897, p. 994.
Liospira helena, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 746.
Liospira helena, *Foerste*, Geol. Surv. Canada, Memoir 83, 1916, pp. 100, 104, 121, 123, 126.

The occurrence at Toronto of a low-spired gastropod of the general type of *Liospira helena, L. vitruvia, L. progue* is undoubted, but the exact specific reference of our form is very questionable. Our whole collection does not contain more than half a dozen examples all of which are compressed, devoid of surface ornamentation, and are destitute of any detail of structure in the basal region. Under these circumstances it seems ill-advised to attempt a specific identification. The best of our specimens show evidence of a concavity on the upper surface of the whorls and thus seem to approach most nearly to *L. helena*. Others might with equal probability be ascribed to *L. vitruvia* or *L. progne*.

Billing's original description of *L. helena* is as follows:

> Sub-lenticular, with an elevated narrowly rounded margin; spire depressed conical; whorls about four, the last one rather strongly concave on the upper side, the others only slightly so. On the under side of the shell the whorls are moderately convex, and the umbilicus closed. The aperture is a little wider than high, the upper part of the inner lip slightly indented by the body whorl, the lower half somewhat vertical, but rounded, the lower part of the outer lip from the umbilicus to the margin of the whorl gently convex, the portion above the margin, concave. In most specimens the suture is enamelled, the shell appearing to be continuous from the apex to the margin, but in some, especially those which are a little worn, it can be more or less distinctly seen; the last whorl usually drops a little below the margin of the next preceding, but even in such instances the suture is not very distinct. In the specimens from shaly rocks no surface markings are visible, but in those from the sandstone of Anticosti, the striae are distinctly visible curving backwards from the suture to the margin. They are very fine in general, but there are occasionally a few coarse ones at distances of half a line or thereabouts from each other. Width from ten to fifteen lines; height a little variable; usually about three fourths of the width.

The best of our specimens shows three whorls, but the total number is uncertain as the apex is broken. The upper surface of the whorls is distinctly concave, but the convexity below the suture, shown by Billings for *L. helena*, is much less pronounced. The suture, therefore, is more sharply defined, and the upper whorls seem to overhang the suture slightly, suggesting *L. abrupta* of Ulrich.

The margin of the body whorl is much thinner and sharper than in Billings' figure, but how far this may be due to compression it is impossible to say. The character of the aperture and umbilicus is not revealed by any of our specimens. The form figured is 22 mm. wide, and about 10 mm. high, measured from the umbilicus to the apex. The apical angle is 120°.

Locality.—Etobicoke river, one mile above Grand Trunk railway bridge.
No. 1202 H.R., Royal Ontario Museum of Paleontology.

Genus LOPHOSPIRA, *Whitfield*

MURCHISONIA AND PLEUROTOMARIA, *Auctores*.
LOPHOSPIRA, *Whitfield*. Amer. Mus. Nat. Hist., 1, 1886, p. 312.
LOPHOSPIRA, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 756. (See for full bibliography).
LOPHOSPIRA, *Ulrich and Scofield*. Geol. Minn., 3, pt. 2, 1897, pp. 951-960.

The description, as given by Ulrich and Scofield, follows:

> Shells with more or less elevated spires; whorls closely coiled throughout or only in the upper part, the last often exhibiting a tendency to become disconnected; whorls angular on the periphery and bearing from one to five distinct carinae; central or peripheral keel strongest and most prominent, carrying the band, which is obtusely rounded, or more or less distinctly trilineate, with the median line heavier and more prominent than the other two; axis rarely, if ever, solid; an umbilicus, usually of very small size, nearly always present. Inner lip generally thickened, often slightly twisted, turning around the umbilicus so as to form a kind of hollow pillar. Outer lip more or less deeply notched, but the centre of the notch, which lies at the peripheral angle, is never prolonged into a slit. Surface markings parallel with the apertural edge; occasionally cancellated by fine spiral lines.

LOPHOSPIRA BEATRICE, *Foerste*

Plate 1, Figure 13.

MURCHISONIA BEATRICE, *Billings*. Geol. Surv. Can., Rep. 1863, p. 209.
LOPHOSPIRA BEATRICE, *Foerste*. Bull. Sci. Lab. Denison Univ., xvii, 1914, p. 310, pl. 2, figs. 8a, 8b.

LOPHOSPIRA BEATRICE, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 757.
LOPHOSPIRA *cf.* PERANGULATA, *Coleman.* XIIth Int. Geol. Cong., 1913, Guide Book, 6, p. 19.

This species belongs to the group of *Lophospira bowdeni* in which the spires are high and consist of from eight to twelve whorls, which are less angular than in the group of *L. perangulata.* As the present species is very closely related to the better known *L. bowdeni,* the revised description of that species given by Ulrich and Scofield is reproduced below:

> Height 40 to 70 mm., usually 45 to 50 mm.; apical angle of Tennessee types of species averaging about 27° but varying between the extremes of 26° and 30°; of the Lorraine group variety 30° to 34°; of the Richmond group from 25° to 28° for specimens from Trimble county, Kentucky, and 27° to 33° for those from Boyle county in the same state; volutions eight to ten, moderately angular, the peripheral band thick, convex, varying as to prominence, situated beneath the centre of the whorls; upper slope convex, sometimes obscurely carinated, in the upper half, more or less concave in the lower half; lower carina obscure, never sharp, often indistinguishable, the space above it to the peripheral carina generally a little concave; a minute umbilicus usually present, though in narrow specimens it is commonly covered by the reflexed inner lip; aperture subtriangular or irregularly quadrate, the outline depending upon the angle at which it is viewed; inner lip nearly vertical, generally exhibiting a small channel in its lower part. Surface with obscure undulations or unequal lines of growth. These are very strongly recurved toward the peripheral band, indicating a large and deep v-shaped notch in the outer lip. The band is distinctly convex, occasionally subangular in the middle, has obscure lunulae, and is bordered on both sides by a delicate raised line.
>
> The prominence of the peripheral band varies considerably. As a rule it is the most pronounced in specimens from the Richmond group and least in those obtained from the "Upper Nashville" of Tennessee and the Lorraine of Kentucky and Ohio. The apical angle also is variable, though fairly constant in specimens from a given locality and horizon. The Lorraine variety is the widest, the Trimble county Kentucky, and Tennessee specimens the narrowest.[1]

Foerste described *L. beatrice* (*op. cit.*) as follows:

> The *Murchisonia beatrice*, Billings, listed in the *Geology of Canada* in 1863 from the Rivière des Hurons is as good a species of *Lophospira* as many another form of this genus, although undoubtedly closely related to *Lophospira bowdeni*, Safford. The specimens figured by Safford represent one extreme of development, with apical angles of 27 to 30 degrees, and with 8 to 10 volutions of which 6 or 7 are usually preserved, the tip being broken off. The characteristic feature of this group of shells is the rather broad and convex peripheral band, situated slightly below the centre of the whorl, varying considerably in prominence but usually far less angular than in most species of this genus. Upper slope flattened or moderately concave toward the peripheral band, angulated or obscurely carinated where it curves into the rather deep sutural area. The lines of growth are strongly recurved toward the peripheral band, as in so many species of the genus. A lower carination or angulation usually obscure but sometimes fairly distinct, ending near the upper margin or the inner lip, is seen on the last volution of some specimens at hand but enough is preserved to indicate that it had essentially the same form as that of *Lophospira bowdeni.* The chief difference between *Lophospira beatrice* and typical *Lophospira bowdeni* consists in its larger apical angle, apparently averaging about 35 degrees but varying from 30 to 38 degrees. This produces a shorter shell, so that the greater number of specimens, in their present state of preservation, present only four or five volutions although the complete shells probably possessed seven or eight.

Although this species seems to occur in some abundance at certain horizons in the strata at Toronto, it is seldom that recognizable examples are found and really well preserved specimens have not yet been seen. Agreement with the type in details of ornamentation, lip-structure, etc., is therefore, inferred rather than observed. In general shape, apical angle, number of whorls, and outline of whorls, our specimens approach very closely the forms figured by Foerste. Plate 1, Figure 13, is drawn from our best specimen, but the lines of growth have been restored from impressions of other shells in the prevailing shale of the formation.

---

[1] Geol. Minnesota, 3, pt. 2, 1897, pp. 986, 987.

The specimen figured measures 34 mm. in height and 17.5 in maximum width. The apical angle is 38°: this is very constant in all specimens measured, as it has not been observed to exceed 40°.

LOPHOSPIRA BEATRICE PARVA, *var. nov.*

Plate 1, Figure 14.

In addition to the species which is herein ascribed to *L. beatrice* our rocks contain a closely related form differing only in size and in a somewhat stronger accentuation of the revolving band. At first sight one is naturally inclined to regard these specimens as young forms of *L. beatrice*: but they occur in considerable numbers on slabs of rock which do not show the larger form, leading to the inference that they represent a separate variety. This inference is strengthened by certain constant differences as follows: the whorls are usually five or six instead of eight and the coiling is freer and more graceful in character. The revolving band is more prominent, and is accentuated above and below by a slight, but well marked depression. All specimens are of nearly uniform size, the height being 17 mm., the width about 8 mm., and the apical angle 40° as in the type of species.

Locality.—Don brickyard, Toronto.
No. 1199 H.R., Royal Ontario Museum of Paleontology.

LOPHOSPIRA TROPIDOPHORA (*Meek*)

Plate 1, Figures 15 and 16.

PLEUROTOMARIA (SCALITES?) TROPIDOPHORA, *Meek*. Geol. Surv. Ohio. Pal., 1, 1873, p. 154, pl. 13, figs. 6a-c.
LOPHOSPIRA TROPIDOPHORA, *Cumings*. 32nd Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1908, p. 969, pl. 41, figs. 2-2d.
LOPHOSPIRA MULTIGRUMA, *Ulrich and Scofield*. Geol. Minnesota, 3, pt. 2, 1897, p. 978.
LOPHOSPIRA TROPIDOPHORA, *Foerste*. Geol. Surv. Canada, Memoir 83, 1916, pp. 84, 116, 123, 130, 133, 135, 158.

Among the uncertain gastropods that appear only on the weathered surfaces of limestone layers are a few that are closely related to, if not identical with *Lophospira tropidophora*. Two of these forms are selected for description: both of them show fairly well the character of the spire, and one indicates the character of the inner lip. The shape of the aperture and the character of the outer lip or of the umbilicus is not shown by any of our forms. While specimens referable with any certainty to this species are very few, it is not to be understood that the species is of rare occurrence because many indications of this type of gastropod are met with on the surfaces of limestone layers.

Lophospira tropidophora is thus described by Meek:

> Shell rather small, obliquely rhombic in general outline, as seen in a side view; height somewhat greater than the breadth; spire conical, with an apical angle of about 70° to 90°; volutions four to four and a half, each flattened, or sometimes slightly concave above, with an outward slope from the suture to a prominent angle that passes around the middle of the body turn, and below the middle of those of the spire, to which it imparts a somewhat turreted appearance; suture moderately distinct, but not channeled; lower side of body volution sloping rapidly inward from the medial angle, a little below which there usually revolves an obscure, undefined ridge; aperture rhombic subquadrate. Surface nearly smooth, but sometimes showing, under a magnifier, very obscure lines of growth, that curve very strongly backward as they approach the angle around the middle of the body volution, both above and below; thus indicating the presence of a deep sinus in the lip, widening rapidly forward, though there is no defined revolving band at the angle.
>
> Length or height, 0.55 inch; breadth, about 0.50 inch.

Ulrich in describing *L. multigruma* which is regarded as a synonym of *L. tropidophora,* says:

> Hight generally from 25 to 35 mm.; greatest width equalling from 75 to 80-100ths of the hight; apical angle 75° to 80°. Volutions five, uniangular; base produced, rounded; umbilicus closed; columellar lip thick and slightly twisted below. Surface markings curved strongly backward to the peripheral band, coarse and rather irregular on the base of the last whorl, much less distinct on the nearly flat upper slope. When perfect the lines of growth are somewhat lamellose.

The two specimens which have been selected to represent this species differ slightly from one another, one resembling Figure 37 and the other, Figure 39 of Ulrich, (*op. cit.*); both of these forms are figured herewith. Our specimens differ from the types in a negative, rather than in a positive manner, *i.e.*, there is no evidence of the character of the aperture, outer lip, or umbilicus, and the secondary ridge below the revolving band has not been observed.

The best preserved specimen is 20 mm. high, and 15 mm. wide, with an apical angle of 73.°

Locality.—Humbervale quarry, Toronto.
Nos. 1206 and 1236 H.R., Royal Ontario Museum of Paleontology.

Family TROCHONEMATIDAE

Genus CYCLONEMA, *Hall*

CYCLONEMA, *Hall.* Pal. New York, 2, 1853, p. 89.
CYCLONEMA, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 330. (See for full bibliography).
CYCLONEMA, *Ulrich and Scofield.* Geol. Minnesota, 3, pt. 2, 1897, p. 1056.

The description given by Ulrich and Scofield follows:

> Shell turbinate or conical, never thick, composed of few more or less ventricose whorls; no umbilicus; surface sculpture consisting of numerous revolving lines and small ridges crossed obliquely by sharp lines of growth; aperture oblique; varying from rounded to subquadrate; inner lip more or less thickened, reflected, always excavated.

CYCLONEMA BILIX (*Conrad*)

Plate 1, Figure 17.

PLEUROTOMARIA BILIX, *Conrad.* Jour. Acad. Nat. Sci. Philadelphia, 8, 1842, p. 271, pl. 16, fig. 10.
PLEUROTOMARIA BILLIX, *Hall.* Pal. New York, 1, 1847, p. 305, pl. 83, figs. 4a-e.
CYCLONEMA BILIX, *Cumings.* 32nd. Ann. Rep. Dept. Geol. Nat. Res. Indiana, 1908, p. 958, pl. 40, figs. 2-2d.
CYCLONEMA BILIX, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 331.
CYCLONEMA BILIX, *Foerste.* Geol. Surv. Canada, Memoir 83, 1916, p. 75.

The description of this species as given by Hall is as follows:

> Obliquely conical; spire short, composed of four or more volutions, which are somewhat appressed above and ventricose below; last volution somewhat flattened on the lower side; aperture rounded, or slightly transverse; surface marked by numerous strong spiral carinae, which frequently alternate with finer ones; these are crossed by fine striae, which, commencing at the top of the volution, pass obliquely backwards to the base, or into the umbilicus, suffering no alteration of their direction upon the carinae.

The occurrence of this species at Toronto has long been accepted, but with the exception of one specimen from Weston (the highest of our strata) our collections show no evidence of the species. It would appear that the listing of *C. bilix* among the Toronto fossils is a survival of the time when "Hudson River" was made to include not only the Lorraine but the Richmond. The single specimen in our old collection said to be from Weston might be regarded as having come from Richmond float were it not that Foerste has recorded the species from that locality. *C. bilix* must therefore be recorded among our fossils, but it is extremely rare and in our experience has not been found elsewhere than at Weston. In fact we have not found a single specimen in our personal collecting.

The specimen figured is 20 mm. high and 21 mm. wide.

Locality.—Weston, Ontario.
No. 1212 H.R., Royal Ontario Museum of Paleontology.

CYCLONEMA, (?) *sp. indet.*

Plate 1, Figure 18.

There is, in our collection from the Don, a single internal cast of a small gastropod, which is too imperfectly preserved to assign to any particular genus. The specimen resembles both *Cyclonema* and *Holopea*. It has been mentioned and figured as an account of our gastropods would be incomplete without reference to this form.

Genus TROCHONEMA, *Salter*

TROCHONEMA, *Salter*. Geol. Surv. Canada, Org. Remains, Dec. 1, 1859, p. 24, 27.
TROCHONEMA, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 1299.

Salter's description of this genus follows:

> Turbinate, thin, of few angular whorls, marked by strong concentric ridges, and crossed by very oblique lines of growth. Umbilicus, wide, open. Inner lip thin, scarcely reflected; peritreme complete.

Ulrich and Scofield in redefining this genus lay stress on the following:

> Whorls not numerous (4-8), varying from strongly angular to rounded, always with two more or less prominent ridges or angles between which lies a broad vertical, usually flat or concave, peripheral space; a third ridge usually near the suture, while a fourth generally surrounds the umbilical cavity.

TROCHONEMA UMBILICATUM (*Hall*)

Plate 1, Figure 19.

PLEUROTOMARIA UMBILICATA, *Hall*. Pal. New York, 1, 1847, p. 43, pl. 10, figs. 9a-h; p. 175, pl. 38, figs. 1a-g.
PLEUROTOMARIA UMBILICATA, *Chapman*. Canadian Jour., n.s., 7, 1862, p. 121, fig. 124.
TROCHONEMA UMBILICATA, *Meek and Worthen*. Geol. Surv. Illinois, 3, 1868, p. 314, pl. 3, figs. 5a, b.
TROCHONEMA UMBILICATA, *Ulrich and Scofield*. Geol. Minnesota, 3, pt. 2, 1897, p. 1047, pl. 77, figs. 1-8.

Hall's description of this common species follows:

> Depressed, nearly discoidal; spire gradually ascending; width about equal to twice the height; spire short; volutions about four, angular and compressed above, ventricose below; suture canaliculated; aperture subrhomboidal, angulated anteriorly; umbilicus large and deep; surface marked with undulating striae.
>
> The last whorl is distinctly marked by three spiral ridges or carinations: one near the suture, one at the upper outer edge, and one at the lower outer edge, leaving the side of the volution plain and vertical; the upper side is angulated by the first carina, and the lower side rounded, scarcely ventricose; the lower angle of the last volution is covered by the spire, the two upper ones continuing. This fossil is readily distinguished, even in fragments, by the distinctly canaliculated suture, elevated upper carina, and the curvillinear depression between this and the next angle.

The occurrence of this species in the strata at Toronto has always been accepted, but, as far as our collections are concerned, it is safe to say that not a single specimen is of really certain identification. Nevertheless, the species in all probability does occur and in considerable abundance, for the shaly layers frequently show examples of a low-spired, thin-shelled, ridged gastropod with very fine lines of growth. These shells are invariably so compressed that their certain identification as *T. umbilicatum* cannot be said to be established.

Lacking any local material of sufficient perfection to assist in illustrating the species we have been forced to make use of the figures given by Ulrich and Scofield.

Suborder CONULARIIDA

Family CONULARIIDAE

Genus CONULARIA, *Miller*

CONULARIA, *Miller*. Sowerby's Min. Conchology, 3, 1821, p. 107.
CONULARIA, *Hall*. Pal. New York, 5, pt. 2, 1879, p. 205.
CONULARIA, *Cumings*. 32nd. Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1908, p. 950.
CONULARIA, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 273. (See for full bibliography).

The peculiar Paleozoic organisms known as *Conularia* have been ascribed to various zoological groups. Following a more or less recognized practice, they are herein ascribed to the division *Pteropoda* of the *Gastropoda*. Later authorities, however, question this relationship and consider that *Conularia* is not a pteropod, but that it resembles more closely certain primitive cephalopods.

Cumings describes the genus as follows:

> Shell rectilinear, inversely conical, rectangular to rhombic in cross-section, with usually sharp edges, acute or truncated posteriorly. Each of the transversely striated or ribbed lateral faces divided into longitudinal halves by a superficial groove, corresponding internally to a median ridge. Posterior portion of the shell divided off by septa. Aperture constricted by four triangular or linguiform incurved lobes of the anterior margin.

CONULARIA FORMOSA, *Miller and Dyer*

Plate II, Figures 4 and 7.

CONULARIA FORMOSA, *Miller and Dyer*. Jour. Cincinnati Soc. Nat. Hist., 1, 1878, p. 38, pl. 1, figs. 12, 12a.
CONULARIA FORMOSA, *Cumings*. 32nd. Ann. Rep. Dep. Geol. Nat. Res. Indiana, 1908, p. 958, pl. 42, fig. 2.
CONULARIA FORMOSA, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 274. (See for full bibliography).

Miller and Dyer describe the species as follows:

> This species in general form is pyramidal, somewhat quadrangular, angles furrowed, and sides somewhat rounded as in *C. trentonensis*. The surface is marked by rounded furrows, separated by obliquely transverse ridges, extending from each angle of the shell diagonally towards the mouth, and meeting those from the opposite angle in the middle of each side. These ridges are ornamented with small nodes or tubercles at the junction with the striae, which cross the furrow on the side toward the apex of the shell. The rounded furrows are crossed by striae, which are about twice as numerous as the transverse ridges, and which terminate on the ridge toward the mouth of the shell in a small tubercle. The longitudinal striae do not cross the transverse ridges, nor are they continued in straight lines on the opposite sides (the magnified view is erroneous in this respect), but on the contrary the striae, which cross the furrows, commence at the ridge toward the apex, at a point between the tubercles, and crossing the furrow toward the mouth terminate at the tubercles.

Our collections contain but few specimens of this species, all from the Don brickyard, and all more or less fragmental. It is also recognized at a level of about 140 feet above Lake Huron in the section at Meaford.

The spacing of the transverse ridges varies from 5 or 6 in a mm. near the apex to 2 near the aperture. The longitudinal striae, where the transverse ridges are 3 to a mm., occur to the number of 5 or 6 in the same distance.

Locality.—Don brickyard.
No. 1215 H.R., Royal Ontario Museum of Paleontology.

CEPHALOPODA

Order NAUTILOIDEA

Suborder HOLOCHOANITES

Family ENDOCERATIDAE

Genus ENDOCERAS, *Hall*

ENDOCERAS, *Hall.* Amer. Jour. Sci. Arts, 47, 1844, p. 109; Pal. New York, 1, 1847, p. 58, p. 207 footnote.
ENDOCERAS, *Hyatt.* Text-Book Paleontology, Zittel-Eastman, 1900, p. 514.

In holochoanitic nautiloids the septal necks reach to the next septum apicad or even beyond. In the *Endoceratida* there are no "tabulae" in the siphuncle which is generally large and completely shut off from communication with the camerae.

In the family *Endoceratidae* the shells are smooth or annulated orthoceracones and the siphuncle is always more or less filled with organic deposits.

The genus *Endoceras* is thus restricted by Hyatt:

> Smooth or annulated orthoceracones. Funnels reach from septum of origination to the next apicad of this, but no farther. Septa pass entirely around the siphuncle. Organic deposits in the form of endocones, and taper off at the centre into a spire that is sometimes tubular and hollow, or again flattened and elliptical. This is the endosiphuncle.

The genus *Cameroceras,* Conrad, antedates *Endoceras* and was originally defined as possessing "a longitudinal septum, forming a roll or involution with the margin of the siphuncle." Hall found no evidence of this septum, and therefore erected *Endoceras* for related forms, leaving only the genotype *Cameroceras trentonense* in Conrad's genus. Later authors have come to regard the two names as co-generic; in consequence, the advocates of priority refer to *Cameroceras* the whole group of forms with long septal necks and endosiphuncular organic deposits. On the other hand the latest writers prefer to retain all these forms in the genus *Endoceras.*

ENDOCERAS PROTEIFORME, *Hall*

Plate IV, Figures 1-4.

ENDOCERAS PROTEIFORME, *Hall.* Pal. New York, 1, 1847, p. 208, pl. 46, figs. 1a-b, 2; 48, figs. 1, 4; 49, figs. 1a-e; 50, figs. 1-3; 52, figs. 1a-b; 53, fig. 1; p. 311; pl. 85, figs. 1a-f.
CAMEROCERAS PROTEIFORME, Clarke. Geol. Minnesota, 3, pt. 2, 1897, p. 777 pl. 48, figs. 1, 2; pl. 49, fig. 2; pl. 50, figs. 1, 2, 3?; pl. 51, figs. 1-3; pl. 53, figs. 4-5.
ENDOCERAS PROTEIFORME, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 483. (See for extended synonymy).

Hall's original description of this species was founded on specimens from the Trenton limestone: in the light of our present knowledge of the nautiloids this description is quite inadequate. The following quotation is the amended description given by Clarke (*op. cit.*):

> It may in a general way be said that *Endoceras proteiforme* is characterized by its enormous size, circular section, comparatively shallow air chambers and great submarginal siphon. The size attained by the species is best indicated by the large cast of the siphon, and entire shells referable to this species have been found with a length of ten to fifteen feet, though all the material before me is of smaller size. The difference in the aspect of these fossils at different parts of their length, where the siphonal tube is variously constructed and the septa subject to variations in distance, renders most appropriate the specific name *proteiforme.*
>
> One of the characters which is very helpful in distinguishing the siphonal casts of this from associated but rarer species of the genus, is the shortness of the siphonal

funnels. The air chambers are themselves shallow, but the funnels seem at times not even to extend from one to the next. . . .

The marginal or submarginal position of the siphuncle explains the obliquity of the septal annulations upon this tube, and the gentle incurvature of the septal funnels, the annulations of this tube.

In the Toronto rocks are numerous examples of large nautiloids with big marginal siphuncles. It has been customary to refer all these specimens to *Endoceras proteiforme.* In the great majority of cases the specimens are fragmentary, crushed, or otherwise distorted: it is impossible, therefore, to determine each individual specimen with any degree of certainty. Few, if any, of the Toronto specimens are sufficiently preserved to justify their use for descriptive purposes. Nevertheless, on the ground of the general resemblance of the fragments to this species we are inclined to refer them all to *E. proteiforme.* The specimens herein described were obtained from more compact layers of rock, presumably of about the same horizon, at Collingwood and in the township of Nottawasaga.

Our finest specimen (Plate IV, Figure 1) was obtained in the township of Nottawasaga. This specimen measures over all 1575 mm. in length. The width near the aperture is 171 mm. The width apicad is not discernible as the shell is much worn. As indicated in the figure the antisiphonal side apicad is much restored and is not reliable. The anterior end seems to be without septa and therefore to represent the body chamber. The condition of preservation of the surface, however, is not sufficiently good to justify the statement that septa are absent in this region. The posterior of this part representing a complete cast, shows three or possibly four sutures. Apicad, the shell and contained rock are broken away to the mid-line, thus exposing the siphuncle. Farther apicad, the siphuncle is broken open in three places exhibiting the characteristic endocones. Apicad of the last endocone, the siphuncle continues for some distance but is irregular, crushed, and devoid of any satisfactory detail.

The septa are strongly convex apicad and throughout the whole length in which they are visible do not seem to decrease materially in spacing, being about 34 mm. apart. The camerae appear to be quite empty. The siphuncular funnels extend to the next septum apicad but, without making a section, the detail of their structure cannot be seen.

The siphuncle anteriorly is 72 mm. wide and decreases gradually apicad. It is marked by diagonally disposed slight elevations just orad of the septal position, while a slight depression marks the general position of the camera. This diagonal marking of the siphuncle is, of course, the result of its marginal position.

The interior of the siphuncle is filled with endocones, observed where the structure is broken. How far orad these extend could not be ascertained without sacrificing the specimen. The apicad extension of the siphuncle is too uncertain to warrant any further remarks. (No. 1234 H.R.)

A second short, but well preserved fragment from Collingwood, (Plate IV, Figure 4), shows the following measurements:

Length	219 mm.	Width of siphuncle orad	80 mm.
Width orad	171 mm.	Width of siphuncle apicad	74 mm.
Width apicad	140 mm.	Average length of camera	27 mm.

The camerae vary in length; but this,, in part at least, is due to distortion. The septa run strongly forward to the suture giving the camerae a pinched appearance towards the periphery. The funnels turn apicad with an inward inflection, but immediately orad of the next septum they expand slightly and again contract to be inserted within the next neck to a distance of about 4 mm. This accounts for the diagonally annulated appearance of casts of the siphuncle. A vertical section was made through the siphuncle of this specimen, but no endocones were seen: it is probably situated too far orad. (No. 952 H.R.)

The best specimens actually found at Toronto consist of a few camerae with the siphuncle protruding apicad: they are always much flattened and seldom reveal any detail of structure. The example figured in Plate IV, Figure 3, is typical. The measurements of this specimen are as follows:

Length of camerae	85 mm.
Width (greatest diameter of flattened shell), orad	83 mm.
" " " " " " apicad	75 mm.
Width (lesser diameter of flattened shell), orad	50 mm.
Width (lesser diameter of flattened shell), apicad	40 mm.
Greater width of siphuncle	41 mm.
Lesser width of flattened siphuncle	18 mm.

A flattened specimen of this kind shows the variation in the length of the camerae, for with a width of shell of 110 mm. (flattened) the average length of the camerae is only 10 mm.

The species undoubtedly attained at Toronto a size comparable with that of the specimens described as we frequently find flattened fragments with a width up to 200 mm. Also fragments of siphuncles of a width as great as shown by the specimens referred to from Collingwood. One of these from Humbervale quarry has a length of 300 mm.

Endocones or perhaps the solid terminal part of siphuncles are of frequent occurrence. When well preserved these are smooth, apparently solid structures tapering to a sharp point. A good example from the Don quarry is 190 mm. long, and only 18 mm. wide at the large end.

Locality.—Nottawasaga, Collingwood, Humber river.
Nos. 1234, 952 and 1235 H.R., Royal Ontario Museum of Paleontology.

Family ORTHOCERATIDAE

Genus ORTHOCERAS, *Breynius*

ORTHOCERAS, *Breynius*. Dissertatio Physica de Polythalamiis, 1832, p. 12.
ORTHOCERAS, *Hyatt*. Zittel-Eastman Textb. Pal., 2nd. ed., 1913, p. 598.

The description of this genus given by Hyatt (*op. cit.*) is as follows:

> Long tapering orthoceracones and cyrtoceracones, smooth, or with only transverse striae and growth bands. Siphuncle generally larger than in *Geisonoceras*, centren or slightly dorsad of centre. Deposits when present gathered about the funnels as in *Annulosiphonata*.

It would appear that the shape of the siphuncular segments alone will not serve to differentiate *Orthoceras* and *Actinoceras* but rather the presence of an endosiphuncle with radiating tubuli in the latter genus.

The definition of "nummuloidal" is insufficient: the term is generally considered to be applicable if the structure is wider than long, but species confidently ascribed to *Orthoceras* have nummuloidal siphuncles within this meaning of the word. See discussion under *Actinoceras*, page 20.

ORTHOCERAS DUSERI, *Hall and Whitfield*

Plate IV, Figures 7 and 8.

ORTHOCERAS DUSERI, *Hall and Whitfield*. Geol. Surv. Ohio, Pal. 2, 1875, p. 97, pl. 3, figs. 2-4.
ORTHOCERAS FOSTERI, *Miller*. Cincinnati Quart. Jour. Sci., 2, 1875, p. 127.
ORTHOCERAS FOSTERI, *Miller*. Jour. Cin. Soc. Nat. Hist., 4, 1881, p. 319, pl. 8, 7, 7a.
ORTHOCERAS DUSERI, *James*. Jour. Cin. Soc. Nat. Hist., 8, 1896, p. 241.
ORTHOCERAS DUSERI, *Foord*. Cat. Foss. Ceph. Brit. Mus., 1, 1888, p. 14.

ORTHOCERAS DUSERI, *Lesley*. Geol. Surv. Penn., Rep. P4, 1889, p. 548.
ORTHOCERAS DUSERI, *Cumings*. 32nd. Ann. Rep., Dept. Geol. Nat. Res. Indiana, 1908, p. 1036, pl. 52, figs. 2-2b.
ORTHOCERAS DUSERI, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 904.

The description given by Hall and Whitfield is as follows:

> Shell of medium size, rather rapidly and gradually enlarging from below upwards, the diameter increasing to twice the size in the space of four and a half inches. Transverse section circular; length of the outer chamber not determined. Septa moderately concave, and closely arranged, but gradually increasing in distance with the increased size of the shell—six chambers occupying the space of one inch where the diameter of the shell is one and a half inches at the upper one of those measured; nearer the point there are ten to twelve in the same distance where the diameter is only three-fourths of an inch. Siphuncle eccentric situated a little nearer to the center than to the margin; very small where it passes through septa, but expanding within the chambers to about four times its diameter at the other point, and forming a flattened bead-like body within each chamber.
>
> Surface of the shell apparently smooth, except that the edges of the septa are raised above the general level, in the form of narrow rings. This feature may possibly be due, in part at least, to an expansion of the septa during the process of petrifaction, but it would scarcely seem to be the case, as the feature is too regular, and only shows where the external shell is wholly or partly preserved. The rings are often some little wider on the surface than the thickness of the septa. Where the surface is most perfectly preserved there is also a finely reticulate or net-like character, dividing the surface into small rhombic figures of microscopic dimensions, having their longest diameters corresponding to the length of the shell, and presenting a surface similar to that frequently produced by the attachment of bryozoans; but the regularity is so great that this cannot have been the origin of the feature; neither have the rhombs anything like a radial structure or direction in any part, as would have been the case if they were the result of the growth of a bryozoan. Along one side of the shell and directly opposite to the position of the siphuncle, there is a narrow, raised, longitudinal line, extending the entire length of the tube, but slightly interrupted just above each one of the annular rings.

Foord (*op. cit.*) makes the following statement:

> Section circular or elliptical (? by pressure) enlarging rather rapidly at the rate of about 1 in 6. Septa closely approximate, but increasing gradually in distance with the growth of the shell, so that they are about one line apart where the shell has a diameter of 5 lines, and about 1½ lines where the diameter has increased to 10 lines, and so on. . . .
>
> Messrs. Hall and Whitfield describe the surface of the shell in *O. duseri* as follows: It has a finely reticulate or net-like character, 'dividing the surface into small rhombic figures of microscopic dimensions etc.' I think these appearances are due to an encrusting Monticuliporoid Coral (Bryozoan), of which I find traces adhering to the specimen in the National Collection.

Foord makes no reference to the external vertical raised line mentioned by Hall and Whitfield.

There seems to be some discrepancy between the statements of these authors as to the rate of increase in diameter. The statement that the shell doubles in diameter in 4½ inches is evidently useless unless the actual diameter is given. Hall and Whitfield's figure, however, shows an increase of 1 in 5.5, which is not essentially different from the figure given by Foord.

We have been unable to find a figure or description accurately defining the siphuncle in this species. In order to ascertain this feature we have cut a typical specimen of *O. duseri* from the Waynesville of Clarksville, Ohio, presented by Dr. Foerste. This specimen corresponds closely with the description of the type, shows the vertical raised line on the antisiphonal side, is encrusted with *Paleschara beani*, and has the siphuncle distinctly excentric in position, and without internal thickenings. The siphuncular segments are moniliform or perhaps nummuloidal as they are distinctly wider than long and the maximum diameter is orad of the mid-length.

The following measurements indicate the character of the camerae and of the siphuncular segments in dorso-ventral section.

Larger end.

Width	20 mm.
Length of camera and siphuncular segment	3.7 mm.
Width of siphuncular segment	5.2 mm.
Ratio of length to width of segment	1: 1.4

Smaller end.

Width	16 mm.
Length of camera and siphuncular segment	2.7 mm.
Width of siphuncular segment	3.7 mm.
Ratio of length to width of segment	1: 1.3

It will be observed that the segments are relatively wider orad. This specimen (No. 12093) is shown in Plate IV, Figure 7.

Hitherto the presence of the "raised line" has been considered sufficient evidence on which to ascribe a specimen to *O. duseri*: this peculiarity is really of no value as it is shown by many other species of *Orthoceras* (See page 22). The slight protrusion of the septal edges in decorticated specimens is also of little value. Without cutting sections, we have only the somewhat closer spacing of the septa as a practical means of separating this species from *Actinoceras crebriseptum*. In sections the species is easily differentiated by the wider siphuncular segments and the absence of the characteristic thickenings of *A. crebriseptum*.

The Toronto specimens ascribed to *O. duseri* are fragments only, but they seem to agree very closely. The antisiphonal line is well marked: the segments of the siphuncle are empty, and correspond closely to those of the specimen from Ohio described above. The spacing of the septa is a little wider than in the Ohio type. A typical fragment is shown in transverse section in Plate IV, Figure 8. In comparing this figure with Figure 7, one must remember that the sections are at right angles to one another.

Locality.—Humber River, Weston, 10 feet below base of scarp on east side. No. 1223 H.R., Royal Ontario Museum of Paleontology.

ORTHOCERAS LAMELLOSUM, *Hall*

Plate IV, Figure 6.

ORTHOCERAS LAMELLOSUM, *Hall.* Pal. New York, 1, 1847, p. 312, pl. 86, figs. 2a-e.
ORTHOCERAS LAMELLOSUM, *Chapman.* Can. Jour., n.s., 8, 1863, p. 20, fig. 127.
ORTHOCERAS LAMELLOSUM, *Chapman.* Expos. Min., Geol. Canada, 1864, 128, fig. 127, p. 172, fig. 192.
ORTHOCERAS LAMELLOSUM, *Nicholson.* Rep. Pal. Prov. Ont., pt. 11, 1875, p. 36, fig. 12b.
ORTHOCERAS LAMELLOSUM, *Ami.* Trans. Ottawa Field Nat. Club, 1, 1882, p. 65.
ORTHOCERAS LAMELLOSUM, *Foord.* Cat. Foss. Ceph., Brit. Mus., 1, 1888, p. 14.
ORTHOCERAS LAMELLOSUM, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 909.
ORTHOCERAS LAMELLOSUM, *Foerste.* Geol. Surv. Can., Mem. 83, 1916, p. 8.

Hall described this species in a very inadequate manner, and as far as we have been able to ascertain, nothing has been published to add any essentials to the original description. It is quite impossible to determine the species by use of the available publications. Nevertheless, *O. lamellosum* has long been recognized as a fossil of frequent occurrence in our rocks. The form to which this name has been given is herein described as *O. lamellosum*: it is undoubtedly different from the other species in our rocks, but that it is really the *O. lamellosum* of Hall is uncertain.

Hall's description follows:

> Slender, very gradually tapering to an acute point; septa distant from one-fifth to one-fourth of an inch, having a convexity about equal to their distance from each other; siphuncle slightly excentric; surface apparently lamellose or subimbricate.

Our collections show several examples, lacking the shell, which externally at least are closely similar to *A. crebriseptum*, but in which the apical angle seems to be larger. These casts also show a distinct antisiphonal raised line as in many specimens of *A. crebriseptum*. This feature seems to have little or no specific value as it is known in a number of species: it is more fully considered on page 22.

The species is represented in our collections by fragments only. The surface is in no case preserved. On the cast the septal edges are markedly even, horizontal and parallel with gradually increased spacing orad. On the antisiphonal side is a "raised line," finer and narrower than in *O. duseri* or *Actinoceras crebriseptum*, and yet quite clearly defined. The siphuncle is somewhat excentric in position, without thickenings of any kind: it is moniliform in shape, but distinctly narrower than in *A. crebriseptum* and much narrower than in *O. duseri*. The available specimens indicate a larger apical angle than in the species mentioned above, but the fragments are too short to justify a definite statement. Measurements of two of our best species are given below:

Length	43 mm.	36 mm.
Width, orad	29 mm.	33 mm.
Width, apicad	24 mm.	28 mm.
Rate of taper	1 in 8	1 in 7
Average length of camera	4.7 mm.	5.5 mm.
Ratio, length to width of camera	1: 5.6	1: 5.5
Ratio, width to length of siphuncular segments	1: 1.3	1: 1.4

Unfortunately these specimens were, by mistake, cut transversely instead of dorso-ventrally: in consequence, the figure of specimen "B" given herewith shows the siphuncle as central in position. The width also is slightly less than indicated by the figures above.

Locality.—Prison quarry, Mimico.
No. 1233 H.R., Royal Ontario Museum of Paleontology.

Family ACTINOCERATIDAE

Genus ACTINOCERAS, *Bronn*

ACTINOCERAS, *Bronn*. Lethaea Geognostica, 1837, Zweite Aufl. Band 1, p. 97.
ACTINOCERAS, *Foord*. Cat. Foss. Ceph. in Brit. Mus., pt. 1, 1888, p. 164.

The genus *Actinoceras* seems to have been established by Bronn and Bigsby's figures published in the Transactions of the Geological Society of London. Stokes accepts Bronn's genus with certain emendations; Barrande discusses in detail the various opinions as to the validity of the genus *Actinoceras*. Most modern writers accept the genus.

The original description of *Actinoceras*, quoted by Barrande is as follows:

> Siphuncle very large, articulated, composed of flattened spheroidal elements with internal rays.

Stokes' definition of the genus is as follows:

> The character of the genus *Actinoceras* is a large siphuncle much dilated in each chamber and contracted at the points where it crosses the septa. In the interior of this siphuncle there is a continuous tube which seems to have been capable of contraction and expansion and (sometimes at least) provided with vertical rays uniting this tube to the walls of the siphuncle.

L. Saemann gives a long dissertation on the nature of *Actinoceras* adopting the opinions of both Bronn and Stokes: *i.e.,* the genus is defined as having expanded siphuncular segments and also internal vertical rays.

This general conception is shared by many authors including Woodward, Roemer, and Eichwald, the latter of whom admits that the radiating lamellae may be replaced by radiating tubes. Barrande, after reviewing the evidence to his time, seems to have been in doubt as to the validity of the genus *Actinoceras.*

Barrande, however, draws attention to an organic thickening of the interior of the siphuncle which usually begins as an annular ring around the necks of the septa and may so extend as to fill the whole of the siphuncular segment not occupied by the endosiphuncle and its tubuli. These organic thickenings were termed by Barrande "anneaux obstructeurs." They are particularly well developed in the *Actinoceratidae,* but are admitted also in the *Orthoceratidae.*

In the practical differentiation of *Orthoceras* and *Actinoceras* several difficulties arise. (*a*) The limitation of *moniliform* as compared with *nummuloid*: *i.e.*, the ratio of the length to the width of the swollen siphuncular segment. It would appear that the segment should be wider than long in order to be described as nummuloidal, but nevertheless many forms are ascribed to *Actinoceras* in which the siphuncle could not be called nummuloidal according to this definition of the term. In doubtful cases, therefore, the shape of the siphuncular segment cannot be relied on to separate *Actinoceras* and *Orthoceras.* (*b*) With regard to the *anneaux obstructeurs*; it is evident from what has been said above that this feature will not serve to differentiate the two genera as these thickenings occur in both, although more strongly developed in *Actinoceras.* (*c*) *Actinoceras* must depend, therefore, on the presence of an endosiphuncle with its radiating lamellae or tubuli: the preservation of these structures is often very imperfect and they are sometimes absent as the calcifications diminish orad and completely disappear in the most anterior segments of a large shell.

Foord's description of the genus follows:

> Shell attaining to a very large size in some species; straight; elongate-conical. Section circular to subcircular. Septa usually more arcuate than in *Orthoceras;* the necks very short and recurved, and often with crystalline deposits ("the anneaux obstructeurs" or "dépôt organique," of Barrande), which sometimes fill the spaces in the siphuncular cavity not occupied by the endosiphon and its canals. Siphuncle very large, the diameter sometimes equalling half that of the shell; much inflated between the septa, so as to present a series of segments of a compressed-globular form. The shelly covering of these segments, which is composed of several layers, is very rarely preserved. The calcified lining membrane of the siphuncle is thrown into a series of folds which impart to it a puckered appearance which is very characteristic. The endosiphon is provided with a distinct wall, and gives off at regular intervals between the septa a number of radiating canals or tubuli, which apparently penetrate the shelly covering or wall of the siphuncle, and, if so, they may have served, as suggested by Owen, for the passage of blood-vessels to the lining membrane of the septal chambers. The spaces between the tubuli are sometimes filled up so that curved transverse partitions, which are formed originally in membrane, and are convex anteriorly, divide the siphuncle into a series of loculi. Nothing is seen of these partitions when the siphuncular cavity has been filled with calc-spar.
>
> The first segment of the siphuncle is in the form of a broadly conical chamber, perforated above the apex by a large foramen, through which the endosiphon passed from the initial chamber into the siphuncular cavity.

ACTINOCERAS CREBRISEPTUM (*Hall*)

Plate II, Figures 2 and 3; Plate III, Figures 1-9.

ORMOCERAS CREBRISEPTUM, *Hall.* Pal. New York, 1, 1847, 313, pl. 86, fig. 2a; pl. 87, figs. 2a-e.

ACTINOCERAS CREBRISEPTUM, *D'Orbigny.* Prodr. Pal. 1, 1849, p. 3.

ORTHOCERAS CERBRISEPTUM, *Billings*. Geol. Surv. Can., Rep. 1863, p. 218, fig. 228.
ORTHOCERAS (ORMOCERAS) CREBRISEPTUM, *Barrande*. Syst. Sil. du Centre Bohême, 2, pt. 3, 1874, p. 739, pl. 434, figs. 6-8.
ORMOCERAS CREBRISEPTUM, *Nicholson*. Pal. Prov. Ont., 1875, p. 37.
ACTINOCERAS CREBRISEPTUM, *Foord*. Cat. Foss. Ceph. Brit. Mus., 1, 1888, p. 173.
ORTHOCERAS CREBRISEPTUM, *Chapman*. Minerals and Geology of Ontario and Quebec, 1888, p. 211, fig. 233.
ORTHOCERAS CREBRISEPTUM, *Chapman*. Outline Geol. Canada, Introduction, p. xxv, pl. IV, fig. 52.
ORTHOCERAS CREBRISEPTUM, *Coleman*. Nat. Hist. of Toronto Region, 1913, p. 61.
ORTHOCERAS CREBRISEPTUM, *Coleman*. XIIth. Int. Geol. Congress, Guide Book No. 6, 1913, p. 10.
ACTINOCERAS CREBRISEPTUM, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 12.

This species has been the subject of considerable discussion particularly as its generic reference is still open to question. Hall's original description is as follows:

> Elongated, conical, somewhat rapidly tapering to an acute apex; septa numerous, approximate, deeply arched, distant about one-seventh the diameter; siphuncle excentric, enlarging in each cell and contracting at its passage through the septum; section circular; surface marked by longitudinal lines, which are visible in the cast.

The best description of this species is given by Barrande (*op. cit.*) and is founded on a specimen from the Hudson River formation of Canada identified and sent to him by Billings. Barrande's remarks are quoted somewhat fully below:

> It is not necessary to discuss here the specific determination of the fossil which we figure and which is composed of a series of air chambers, exposed in a longitudinal section. The authority of Mr. Billings satisfies us on this point.
>
> One may see from this fragment that the shell is elongated. But, as most of the chambers are broken on the right side, the apical angle which appears to be about 2° near the small end may have been modified by compression. The cross section is circular.
>
> The suture is almost horizontal but this statement must not be taken without doubt. The spacing of the septa is somewhat irregular—between 3 and 7 mm. in the 18 chambers observed. The curvature can be considered as about one-fifth of the corresponding diameter. . . .
>
> It may be observed towards the lower end of the fossil which appears to be the best preserved that the lines representing the sections of the septa indicate a breaking on the right of the siphuncle, for they do not form complete curves.
>
> In the space corresponding to the air chambers on the right side the débris of the septa may be observed. Each piece is covered on both sides by a thin layer of white silica which also extends around the ends. We find these same layers on the perfect septa towards the lower end of the fossil. This appearance, together with that of the rock which occupies the whole space indicates sufficiently the absence of an organic deposit in this part of the *Orthoceras*. As it is relatively the larger part with respect to the siphuncle it would seem, on the contrary, the most disposed to reveal this deposit.
>
> But, in the part to the left of the siphuncle, we observe a ribbon-like deposit of a chemical nature which might be misinterpreted as to its origin. However, as this structure is formed in the same manner as the siliceous layer which covers immediately all the surfaces of the air chambers and that of the siphuncle, we can consider it only as derived from an inorganic source. We see that this deposit, well indicated in the seven lower chambers, disappears in the upper chambers.
>
> The siphuncle, placed off the axis at the small end, is excentric throughout the whole length, and its excentricity diminishes gradually towards the top. One could even predict that in a longer specimen the siphuncle would attain a central position near the larger end. It would also become submarginal near the small end. We have noticed a similar obliquity of the siphuncle with respect to the axis of *Orthoceras* in different species of Bohemia.
>
> The elements of the siphuncle are a little cordiform, *i.e.*, their width at the summit is greater than at the base. They are also a little oblique on account of the marked excentricity. The maximum diameter does not reach 6 mm. and the corresponding height 7 mm. Thus they approach nearer to the cylindrical than to the nummuloidal form in the upper part of the fragment. On the contrary, towards the lower end, the height and the width tend to become equal in each element.

The organic deposits seem to be represented in the eight lower elements, but in an unusual form, which we have not hitherto seen in any other species except *O. palemon* of Bohemia. The unusual feature in the occurrence of this deposit is that it is formed on one side only of the siphuncle—the left in the figure. Their section pyriform, elongated, and a little irregular extends from the neck throughout the whole length of the element. We see, on the contrary, no trace of this deposit on the opposite wall. This distribution seems to be the extreme limit of a generally observed occurrence, for *l'anneau obstructeur* is always more developed on one side of the siphuncle than on the other.

The specimen described has a length of nearly 106 mm. Its diameter at the small end is about 21 mm.

The elements of this species which we know do not permit us to compare it in detail with analogous forms from the same country. We have nothing in Bohemia which can be considered as closely related to it.

It has been a common practice to ascribe to this species most of the specimens of *Orthoceras* found at Toronto. As nearly all specimens are imperfect and very seldom retain the external shell, one is generally unable to make use of the characteristic vertical lining as a means of determination. The mere spacing of the septa and the rate of tapering are of doubtful value, especially in fragmentary material. Further, as the identity of the species depends so much on the peculiar character of the siphuncle and internal thickenings, it becomes necessary, practically in each case, to prepare a section through the shell. Many specimens show the characteristic features as described by Barrande with the one exception that the siphuncle does not tend to become central towards the aperture. On the contrary, it seems in most cases to become more excentric.

A feature of many specimens of *A. crebriseptum* is the presence of a more or less marked antisiphonal raised line on casts of the interior. Unfortunately this peculiarity is of little use for the identification of the species as it is seen also in *Orthoceras duseri* and *O. lamellosum* from our rocks.

This raised line is given prominence by Barrande in all his descriptions of Paleozoic cephalopods and is discussed in detail in Chapter XIII, Vol. II, Pt. V, Système Silurien de la Bohême. The appearance is called *la ligne normale* and is thus described by Sandberger:

> *La ligne normale*, which we find very clear and distinct in *Bactrites gracilis* and *B. subconicus*, and also in a great number of species of *Orthoceras*, shows itself on the surface of the internal mould of these fossils as a longitudinal keel more or less clearly marked. Its form varies in different species, for it is sometimes simple, sometimes multiple; thus, it is triple in *Orthoceras undatolineolatum*. According to the state of preservation and the nature of the fossilizing substance, it is sometimes visible on all the chambers, or it appears, on the contrary, only here and there on certain ones.

It would appear from Barrande's conclusions that this line is individual rather than specific: that it is sometimes a raised line (carène) or a depressed line (en creux): that it sometimes shows on the living chamber only, and sometimes only on the camerae; and that it may be either siphonal or antisiphonal in position.

La ligne normale was observed in 61 out of 525 species of *Othoceras* from the Silurian rocks of Bohemia and in 77 out of 1,014 species of cephalopods.

Many specimens of *A. crebriseptum* show this line on the camerated part of moulds: we have not observed it on the body chamber. It is frequently absent but this may be only accidental as all such specimens are of necessity more or less imperfect.

The most typical *A. crebriseptum* in our collections is a fragment 80 mm. long, 20.5 mm. wide at the larger end, and 12.5 mm. at the smaller end. The shell is intact and quite smooth on the siphonal side, but with well marked longitudinal striae on the antisiphonal side; these extend about one-third of the total circumference of the shell. (Plate II, Figure 3).

In the ten camerae at the small end the septa average 3.2 mm. apart. The ratio of length to width is therefore 1: 5. The siphuncle is slightly excentric apicad and tends to become more so orad.

The siphuncular segments (Plate III, Figure 4), are moniliform in shape and slightly longer than wide. Assuming the siphuncle to be ventral in position (right in figure) the organic deposits within this structure seem to be confined to the ventral side and to be less developed orad. Unlike other specimens, this example shows a hollow within the thickenings which is filled with crystalline calcite. The remaining parts of the siphuncle are filled with clay (dotted). It will be noted that these organic deposits do not exactly correspond with those described by Barrande; they are similar, however, in being related to the ventral side.

The camerae on the siphonal side are completely filled with a dense sort of calcite which sometimes displaces the septa: it is arranged in a botryoidal manner and evidently was formed from shell inwards. This type of filling extends to the antisiphonal side, but here it is slightly developed forming a lining on the inner side of the shell proper and extending a short distance inward on the orad side of the septa (lined in figure). From the evidence derived from this specimen and from that furnished by others described below, it would appear that this material is inorganic in origin, formed after the death of the animal, but occasioned by some organic substance within the camerae which was largely confined to the ventral side.

The four apicad septa on the antisiphonal side were filled with clay (dotted) immediately after the deposit described above was formed. The fifth was only partly filled with clay. Those camerae into which clay did not find its way—the four orad camerae—were lined with a thin layer of fine fibrous calcite, and at a later time, the interiors were filled with crystalline calcite of the same character as that which fills the space in the centre of the siphuncular thickenings. (No. 1225 H.R.)

A second specimen with the test preserved (Plate III, Figure 8), consists of a fragment near the apex: it is about 44 mm. long; 18 mm. wide orad, and 12 mm. wide apicad. There are 12 camerae giving an average length of 3.7 mm., and a ratio length to width of 1: 3.6. This specimen has the septa more widely spaced than in the form described above: in consequence, the siphuncular segments are more elongated. The figure shows a transverse, instead of a dorso-ventral section. The inorganic thickenings in the camerae appear, therefore, in a marginal position on the outer sides of the camerae. The organic thickenings within the siphuncle present more the appearance of rosettes over the septal necks, and show also, orad at least, the endosiphuncular space. The unoccupied parts of both siphuncle and camerae are filled with a dense, partially silicified calcite (vacant in figure). The fibrous layer, however, can be made out in places.

This example bears a striking resemblance, in spacing of septa, and in the shape of the siphuncular segments to *Orthoceras mohri*, Miller. In view, however, of the characteristic thickenings, it seems impossible to remove it from *A. crebriseptum*. (No. 1230 H.R.)

Another somewhat similar specimen is shown in Plate III, Figures 7 and 7a. Figure 7 represents a transverse section, and Figure 7a, a dorso-ventral section of the siphonal side. The fragment is 40 mm. long, 17 mm. wide orad, and 10 mm. wide apicad. There are 15 camerae, giving an average length of 2.6 mm. and a ratio of length to width of 1: 5.2. In regard to the spacing of the septa, therefore, there seems to be some variation, as these three specimens, approximately of the same size, show respectively a spacing of 3.2 mm., 3.7 mm., and 2.6 mm.: but, reduced to the ratio of length to width, the difference is less apparent, *i.e.,* 1: 3.6 to 1: 5.2.

This specimen is of particular interest in that it shows in a most defined manner the inorganic thickening in the camerae. In the transverse section it appears on both sides as clear structureless calcite lining the external wall of the camerae and extending inwards on the orad side of the septa (dotted in figure). On the siphonal side (Figure 7a) it is much thicker and botroyoidal in structure. The camerae which have been filled with clay (crosses in figure) show a sharp definition of the boundaries of this inorganic layer. All other open parts are lined with the fibrous layer and filled with crystalline calcite as in the other cases.

The siphuncle is not well preserved, indistinct thickenings only being observed. In the figure it is indicated as being entirely filled with clay. (No. 1229 H.R.)

The three specimens described above are all small and represent either young individuals or the apical end of larger individuals, more likely the former. The larger fragments are described below.

One very typical example is shown in dorso-ventral section in Plate III, Figure 2. The fragment is 46 mm. long, 21 mm. wide at the large end, and 14 mm. wide at the small end: it contains 13 camerae which increase in length orad but not regularly. The average length of a camera is 3.5 mm., and the average width is 17.5 mm. The ratio of length to width is, therefore 1: 5.

The shell is not preserved; it appears to have been very thin as likewise the septa and the siphuncular sheaths. The siphuncle is but slightly excentric—less so than in some other examples.

This specimen reveals essentially the same features which have been described in the case of No. 1225 H.R. The chief difference is that the siphuncular thickenings do not exhibit an internal cavity. This organic thickening, however, is very dense and badly preserved in this instance: the lining shown in the figure is much overdrawn. The secondary character of the calcite on the siphonal side (left in figure) of the camerae is indicated by the fact that the septa are broken by the growth of this matter. It is also to be observed that the calcite has formed around certain centres as in the case of small particles of clay adhering to the septa in places. On the antisiphonal side a thin layer of similar calcite (lined in figure) formed on the outer wall of the camerae and extended inwards on the orad side of the septa. Where infiltered with clay the camerae show no fibrous layer. Where there is no clay the fibrous layer occurs and the centre of the space is either empty or filled with crystalline calcite.

Locality.—Prison quarry, Mimico.
No. 1219 H.R., Royal Ontario Museum of Paleontology.

Another fragment, also without either striae or raised line, shows relatively longer camerae than the example just described and seems to indicate a trace of an endosiphuncle.

This fragment is 25 mm. long and shows six camerae in that distance: the maximum width is 20 mm. and the minimum 15 mm. The average camera is 4.2 mm. long and 17.5 mm. wide; the ratio of length to width is, therefore, 4.2:

17.5, which equals 1: 4.2. The section was cut to pass through the siphuncle (Plate III, Figure 5) in a plane at right angles to the dorso-ventral; in consequence, the siphuncle appears central and the camerae on both sides present the same features. It would appear that the inorganic ventral calcification in the camerae extends above the midline as it appears towards the outer walls on both sides and increases in amount apicad. The thin fibrous calcification is evidently later. The interesting point revealed by this specimen is the trace of a distinct endosiphuncle which has a tubular appearance in the first four segments orad; it seems to effect a communication with the camerae in the second section from the anterior end. In the two apicad segments its identity is lost. In the drawing, the clay filling the endosiphuncle is figured as in the case of the filling of the camerae (fine dotted). The clay filling of the rest of the siphuncle is more coarsely dotted and whilst diagrammatic, it nevertheless expresses the fact of a different texture being apparent in the two parts. (No. 1220 H.R.)

Another very good specimen (Plate III, Figure 3) showing the structure towards the small end and the gradual loss and final disappearance of both the siphuncular and ventral thickening orad is described below. It is unfortunate that this specimen, also, shows neither striae nor raised line externally as the shell is lost.

This is an excellently preserved fragment 66 mm. long, 23 mm. wide at the larger end and 14 mm. wide at the small end. It contains 20 camerae. The average length of a camera is, therefore, 3.3 mm., and the average width is 18.5 mm. The ratio of length to width is 3.3: 18.5. *i.e.,* about 1: 5.6.

The section is cut in the dorso-ventral plane and shows that the siphuncle in this case is but slightly excentric; further, it does not seem to become more central towards the aperture. This specimen shows in a marked manner the difference between the antisiphonal and siphonal filling of the camerae. The ventral calcification already referred to, seems to fill the whole of the three apicad segments. This, however, is unexpected and may possibly be due to the inability to differentiate different types of calcite. On the antisiphonal side it could as well be interpreted as an unusual development of the fibrous layer. From this point forward the ventral calcification is restricted to the ventral side and fills all the space between the walls, septa, and siphuncle as far forward as the sixteenth camera inclusive. Orad of this it gradually decreases in amount, being confined to the side towards the shell; the remainder of the ventral part of the camera being filled with clay.

On the antisiphonal side of the siphuncle, excepting the three apicad segments, the camerae are lined with the fine fibrous layer already referred to, and variously filled with clear crystalline calcite. The extension of the ventral type of calcite as a thin layer on this side is not observed as the peripheral part of the specimen has been eroded.

The siphuncle is identical in shape with that of the specimens already referred to. The average maximum width of the moniliform segments is 3.2 mm. and the length 3.3 mm. They are, therefore, slightly longer than wide.

The organic thickenings within the siphuncle are excellently shown. They are confined to the ventral side and decrease in amount orad, disappearing with the sixteenth segment except for a minute occurrence in the seventeenth.

This siphuncular thickening shows very indistinctly the ribbon-like character ascribed to these structures. In places there is a slight indication of "rosettes" but on the whole it is more of a wavy and indistinct character. This feature is rather overdrawn in the figure.

Locality.—Prison quarry, Mimico.
No. 1221 H.R., Royal Ontario Museum of Paleontology.

In all our collections we have only one specimen that shows the body chamber (Plate III, Figure 1): it is about 185 mm. long in all: the body chamber is 56 mm. in length. The chambered portion shows 27 camerae varying somewhat in length at the smaller end, but becoming distinctly more closely spaced towards the aperture. The specimen is bent and flattened: in consequence the rate of tapering as shown in the drawing may not be quite accurate. The outer shell is absent, leaving us in doubt as to the occurrence of striae externally. In places there is a faint indication of a "raised line." A section of the lower part of this specimen shows the internal structure typical of the species, but the siphuncle is more markedly excentric.

Locality.—Humber River, Toronto.
No. 941 H.R., Royal Ontario Museum of Paleontology.

The specimen above described seems to have reached its maximum growth as indicated by the crowding of the septa near the living chamber; nevertheless, we find broken pieces of larger size which must be provisionally ascribed to this species. As they are all orad of the region of siphuncular thickening the shape and spacing of the elements alone indicate a reference to *A. crebriseptum*, but the position of the siphuncle in no case shows the approach to the centre mentioned by Barrande.

One of the best fragments of this kind (Plate III, Figure 9) gives the following measurements:

Length	80 mm.
Width at larger end	44 mm.
Width at smaller end	29 mm.
Average length of camera	6.1 mm.
Ratio of length to width of camera	1:6

This specimen might as well be ascribed to *O. lamellosum.*

Locality.—Prison quarry, Mimico.
No. 1222 H.R., Royal Ontario Museum of Paleontology.

As already stated many internal casts show a distinct longitudinal "raised line" on the antisiphonal side. Hitherto we have been accustomed to ascribe such forms to *Orthoceras duseri*, but the examination of a great many longitudinal sections prove that these forms differ in no way from *A. crebriseptum.* Without sections it is difficult to separate the two species, but in good specimens the present species may be differentiated by the wider spacing of the septa orad.

A good example (Plate II, Figure 2: Plate III, Figure 6), shows no essential difference from those already described except in the occurrence of the "raised line." The spacing and curvature of the septa are the same and the peculiar siphuncular thickenings and the inorganic deposits on the siphuncular side are identical. It will be observed that the antisiphonal side is so weathered that the external portions of the camerae are lost. A very critical comparison shows a slightly greater relative width for the siphuncular rings and a somewhat more marginal position for the siphuncle. The following measurements indicate the proportions of this specimen:

Length	100 mm.
Width at larger end	32 mm.
Width at smaller end	26 mm.
Contains 20 camerae.	
Length of apicad camera	3.5 mm.
Length of orad camera	6 mm.
Ratio of length to width of camera, orad	1: 5.3

Ratio of length to width of camera, apicad	1: 7.4
Width of siphuncular segment, apicad	3.5 mm.
Ratio of width to length of segment	1:1

(Anteriorly the segments are relatively narrower).

Locality.—Prison quarry, Mimico.
No. 1226 H.R., Royal Ontario Museum of Paleontology.

ACTINOCERAS *cf.* CLOUEI (*Barrande*)

Plate IV, Figure 5.

ORTHOCERAS CLOUEI, *Barrande.* Syst. Sil. du Centre Bohême, ser. 2, 1870, pl. 432, figs. 1-6; pl. 433, figs. 1, 2; pl. 434, figs. 1-5.

ORTHOCERAS CLOUEI, *Barrande.* Syst. Sil. de la Bohême, texte, Vol. 2, Part 3, 1874, p. 718.

ACTINOCERAS CLOUEI, *Parks.* Palaeoz. Foss. Region, S.W. of Hudson Bay, Trans. Royal Can. Inst., 1915, p. 86; pl. 2, fig. 6; pl. 6, fig. 1.

This species was established by Barrande on specimens from Newfoundland. According to his description, the shell is sometimes slightly curved, sometimes straight: the section is nearly circular, but in some instances slightly elliptical. The siphuncle is near one side—in curved forms, the concave side. The apical angle varies from 9° to 16°. The sutures are fairly regular and horizontal, and the spacing of the septa increases with the diameter of the shell, but does not exceed 10 mm. The curvature of the septa is about one-fifth of their greatest diameter. The largest specimen measures 210 mm. in length with a maximum width of almost 80 mm.

The camerae are more or less filled with a deposit which Barrande considers of organic origin. This forms on both sides of the septa; apicad it fills the whole camerae: orad it is less developed leaving an open space in the middle of the camera.

The form of the siphuncular elements is nummuloidal and notably flattened, the width is to the length as 5 to 2. The *anneaux obstructeurs* are strongly developed.

The Toronto collections have yielded a single specimen which is with much hesitation provisionally ascribed to this species. The fragment is 79 mm. long. The antisiphonal side is entirely crushed making it impossible to state the width with certainty, but it was probably 28 mm. wide at the larger and 18 mm. at the smaller end.

In this distance are 19 camerae, making the average length of each nearly 4 mm. The surface appears to be smooth.

A vertical section in the dorso-ventral plane reveals a siphuncle characteristic of the genus *Actinoceras* and strikingly different from that of any other of our specimens. The siphuncular segments are inclined to the axis of the shell on account of the marginal position of the siphuncle: they are distinctly nummuloidal and about 20 mm. wide and 11 mm. long at the larger end. The siphuncle is almost filled with organic deposits, the *anneaux obstructeurs* of Barrande, which are disposed as concentric "rosettes" around the septal necks.

The camerae on the ventral side (right in figure) are almost filled with a deposit of calcite apparently similar to the organic deposits of Barrande. On the antisiphonal side none of this is seen, but, as the shell and septa are entirely destroyed in this region, its absence may be due to imperfection. It seems strange, however, that so solid a structure would entirely disappear on one side and be so perfectly preserved on the other.

In the figure (Plate IV, Figure 5), the eight camerae apicad are shown at the lower end. The section is almost through the centre of the siphuncle apicad;

higher up it is a little to one side. On the right the siphuncular sheaths are apparent, but on the left they are destroyed; on this side also the radiating tubuli are well shown. The septa on the right side are somewhat restored; in the specimen they are undulating and somewhat broken.

This specimen is unique in our collections; it is ascribed to *A. clouei* with great doubt. The resemblance to this form is seen in the character of the siphuncle, its internal thickenings, and its marginal position; also, in the "organic deposits" in the camerae. It differs from *A. clouei* in its smaller size and in the less flattened siphuncular segments.

Locality.—Humbervale quarry.
No. 1228 H.R., Royal Ontario Museum of Paleontology.

VERMES

Order ERRANTIA

Although the jaws of errant annelids are known to occur in considerable abundance at Toronto, only a limited number of specimens appear in our collections. Under such circumstances, we are unable to add any information to the account published in 1879, in the Quarterly Journal of the Geological Society of London, by Dr. G. J. Hinde. It has been thought advisable, therefore, to reproduce Dr. Hinde's entire text with accompanying plates. The only additions are the generic descriptions and the synonymy.

Genus EUNICITES, *Ehlers*

EUNICITES, *Ehlers*. Paleontographica, 17, 1868, p. 147.
EUNICITES, *Zittel*. Handb. Pal., 1, 1880, p. 565.
EUNICITES, *Miller*. N.A. Geol. Pal., 1889, p. 518.
EUNICITES, *Grabau and Shimer*. N.A. Index Fossils, 1910, 2, p. 241.
EUNICITES, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 510.

Grabau and Shimer's description of this genus follows:

> Minute, elongate, denticulate jaws with numerous teeth; subquadrate jaws with few teeth; simple, more or less curved, narrow hooks without denticles.

EUNICITES MAJOR, *Hinde*

Plate V, Figure 1.

EUNICITES MAJOR, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 374, pl. 18, fig. 1.
EUNICITES MAJOR, *Grabau and Shimer*. N.A. Index Fossils, 2, 1910, p. 241, fig. 1530a.
OENONITES MAJOR, *Miller*. N.A. Geol. Pal., 1889, p. 519.
EUNICITES MAJOR, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 511.

Hinde describes the species as follows:

> Jaw oblong, somewhat flattened, the upper edge curved inwards; the posterior end truncated, with a deep furrow leading to an oval central depression, from which a cavity apparently extends under the front portion of the jaw; the furrow is bounded above and below by rounded ridges. At the front of the jaw are two stout blunted teeth, and the upper edge carries seven or eight short, subequal, rounded teeth.
>
> This is an abundant form, though perfect specimens are rarely met with. It varies greatly in size; the smaller examples are about 1 line long, whilst the largest, as in the specimen figured, are 3½ lines in length and 1⅛ wide. It may be distinguished from *E. (Nereidavus) varians*, Grinnell, by its truncated extremity and the median furrow and cavity.

EUNICITES (Nereidavus) VARIANS, *Grinnell*

Plate V, Figures 2, 3 and 5.

NEREIDAVUS VARIANS, *Grinnell*. Amer. Jour. Sci., 3rd ser., 14, 1877, p. 230, figs. 1, 2.
NEREIDAVUS VARIANS, *Miller*. N.A. Geol. Pal., 1889, p. 519, fig. 939.
EUNICITES (Nereidavus) VARIANS, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 375, pl. 18, figs. 2, 3, 5.
NEREIDAVUS VARIANS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 852. (See for full synonymy).

The description by Hinde follows:

Jaw elongated, curved, rounded in front, and convex, widest about one-third the length from the anterior end, and then gradually tapering to a point, the front portion somewhat larger than the rest; succeeding this are from two to five, blunted, rounded, upright teeth, and then a series, varying in different specimens, of from nine to fourteen pointed teeth. These latter gradually diminish in size towards the posterior end, and are uniformly directed backwards. The dimensions of the specimens figured are as follows:—fig. 2, 2 lines long and ½ line wide; fig. 3, 2⅛ lines long and about ¼ line in width; fig. 5, 3⅛ lines long and ⅞ line wide. Abundant.

Eunicites contortus, *Hinde*

Plate V, Figure 4.

Eunicites contortus, *Hinde.* Quart. Jour. Geol. Soc. London, 35, 1879, p. 375, pl. 18, fig. 4.
Eunicites contortus, *Grabau and Shimer.* N.A. Index Fossils, 2, 1910, p. 241, fig. 1530d.
Eunicites contortus, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 510.

Hinde's description follows:

Jaw elongated, very narrow, and tapering to a point, the anterior tooth prominent, nearly upright, not in plane with the rest, and followed by a uniform series of about seventeen pointed teeth, which are all directed backwards, parallel with each other. Length about 1⅛ line.

Eunicites perdentatus, *Hinde*

Plate V, Figure 6.

Eunicites perdentatus, *Hinde.* Quart. Jour. Geol. Soc. London, 35, 1879, p. 375, pl. 18, fig. 6.
Lumbriconereites perdentatus, *Miller.* N.A. Geol. Pal., 1889, p. 519. (gen. ref.).
Eunicites perdentatus, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 511.

Hinde gives the following description:

Jaw extremely small, narrow, and gently curved; the anterior end elevated and bent inwards; on this portion are two or three rounded teeth, which are followed by a series of about twenty very minute, subequal, acutely pointed teeth. Length ⅝ line. Abundant.

Eunicites simplex, *Hinde*

Plate VI, Figure 2.

Eunicites simplex, *Hinde.* Quart. Jour. Geol. Soc. London, 35, 1879, p. 376, pl. 19, fig. 2.
Eunicites simplex, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 511.
Eunicites simplex, *Grabau and Shimer.* N.A. Index Fossils. 2, 1910, p. 242, fig. 1528b.

The description by Hinde follows:

Jaw consisting of a simple, slightly curved hook, narrow throughout, and angular in section. Length 1⅛ line.

Eunicites gracilis, *Hinde*

Plate VI, Figure 3.

Eunicites gracilis, *Hinde.* Quart. Jour. Geol. Soc. London, 35, 1879, p. 376, pl. 19, fig. 3.
Eunicites gracilis, *Grabau* and *Shimer.* N.A. Index Fossils, 2, 1910, p. 242, fig. 1528c.
Eunicites gracilis, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 511.

Hinde's description follows:

Jaw composed of a nearly straight, slightly convex basal portion with a strongly curved anterior hook. Length 1 line, about ¼ line in width.

Eunicites ? digitatus, *Hinde*

Plate VI, Figure 13.

Eunicites ? digitatus, *Hinde.* Quart. Jour. Geol. Soc. London, 35, 1879, p. 376, pl. 19, fig. 3.
Eunicites ? digitatus, *Bassler.* U.S. Nat. Mus., Bull. 92, 1915, p. 511.

Hinde describes the species as follows:

Jaw very small, triangular, and nearly equilateral. At one extremity are two slender, elongated, nearly straight teeth, behind which, on the straight upper border, are seven minute rounded teeth. Length of upper edge about ⅜ line.

Genus OENONITES, *Hinde*

OENONITES. *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 376.
OENONITES. *Miller*. N.A. Geol. Pal., 1889, p. 519.
OENONITES, *Grabau and Shimer*. N.A. Index Fossils, 2, 1910, p. 242, fig. 1532c.
OENONITES, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 868.

Hinde gives the following description of the genus:

Jaws with a more or less curved anterior hook, followed by a series of smaller teeth, similar in character to those of the existing genus *Oenone*.

OENONITES CURVIDENS, *Hinde*

Plate V, Figure 7.

OENONITES CURVIDENS. *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 376, pl. 18, fig. 7.
OENONITES CURVIDENS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 868.

Hinde's description follows.

Jaw nearly straight, with a strongly convex ridge, forming the lower portion of the base; in front a relatively large, very strongly curved tooth, obliquely bent: this is succeeded by fourteen small pointed teeth, carried on a very narrow flattened ridge. Length ¾ line, about ¼ line in width.

OENONITES INAEQUALIS, *Hinde*

Plate V, Figure 8.

OENONITES INAEQUALIS. *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 376, pl. 18, fig. 8.
OENONITES INAEQUALIS. *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 869. (See for full bibliography).

Hinde gives the following description:

Jaw nearly straight, tapering to a point; a small projecting appendage below the anterior part of the base, a slightly curved and blunted anterior tooth, succeeded by three minute blunted teeth behind which are six or seven larger acutely pointed teeth. Length 1 line, width rather more than ¼ line.

OENONITES SERRATUS, *Hinde*

Plate V, Figure 9.

OENONITES SERRATUS. *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 376, pl. 18, fig. 9.
OENONITES SERRATUS, *Grabau and Shimer*. N.A. Index Fossils, 2, 1910, p. 242, fig. 1526a.
OENONITES SERRATUS. *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 869. (See for full bibliography).

Hinde gives the following description:

Jaw elongated, narrow, the toothed border slightly arched, truncated at the posterior end, which is wider than the front portion of the jaw, and is slightly concave, with a narrow median furrow. The anterior tooth is but slightly curved, behind which are, first in order, four very small rounded teeth, and then a series of twelve very minute pointed teeth. Length ⅝ line.

OENONITES ROSTRATUS, *Hinde*

Plate V, Figure 10.

OENONITES ROSTRATUS. *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 376, pl. 18. fig. 10.
OENONITES ROSTRATUS, *Grabau and Shimer*. N.A. Index Fossils, 2, 1910. p. 242, fig. 1526b.
OENONITES ROSTRATUS. *Bassler*. U.S. Nat. Mus., Bull. 92, p. 869.

The following description is given by Hinde:

> Jaw relatively short, very wide and truncate; a deep furrow just below the toothed edge, extending from the middle to the truncated extremity, and below the termination of the furrow is a projecting knob-like elevation; a stout curved tooth in front, behind which are four claw-shaped teeth, followed by five founded teeth. Length ¾ line, width ⅜ line nearly.

OENONITES CUNEATUS, *Hinde*

Plate V, Figure 11.

OENONITES CUNEATUS, *Hinde*, Quart. Jour. Geol. Soc. London, 35, 1879, p. 377, pl. 18, fig. 11.
OENONITES CUNEATUS, *Grabau and Shimer*. N.A. Index Fossils, 2, 1910, p. 242, fig. 1526c.
OENONITES CUNEATUS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 868.

Hinde describes the species as follows:

> Jaw small, compressed, widest in the central portion and tapering gradually to the blunted extremity; a slightly curved anterior tooth, and on the nearly straight upper edge twelve subequal, very minute, rounded teeth. Length ½ line.

OENONITES ? CARINATUS, *Hinde*

Plate VI, Figure 19.

OENONITES ? CARINATUS, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 377, pl. 19, fig. 19.
OENONITES ? CARINATUS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 868.

The description by Hinde is as follows:

> Jaw elongate, truncate posteriorly, the front portion slightly convex; a very stout anterior tooth, and towards the end of the jaw five minute blunted teeth on an angular ridge; the central portion of the jaw beneath the ridge deeply concave. Length ⅝ line.

Genus ARABELLITES, *Hinde*

ARABELLITES. *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 377.
ARABELLITES, *Miller*. N.A. Geol. Pal., 1889, p. 517.
ARABELLITES, *Grabau and Shimer*. N.A. Index Fossils, 2, 1910. p. 240.
ARABELLITES, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 57.

Hinde describes the genus as follows:

> I propose to include in this genus jaws of widely different form, which have a general resemblance to those of the existing genus *Arabella*, Grube. 1. Jaws with an extremely prominent anterior hook, and a row of smaller teeth on a wide base; 2. Sickle-shaped jaws and allied forms; 3. Jaws subquadrate in form, with a straight upper edge of small teeth. Those of the first division appear to correspond with the first pair, the second resemble the second pair, as figured in Cuvier's 'Regne Animal,' of *Arabella* (*Oenone*) *maculata*, Edwards; whilst the square-shaped jaws I regard as belonging to the lower jaw of Annelids of this genus. Examples of these different forms are very abundant, not only in the Cambro-Silurian, but in all the other formations where the Annelid remains appear.

ARABELLITES HAMATUS, *Hinde*

Plate V, Figure 12.

ARABELLITES HAMATUS, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 377, pl. 18, fig. 12.
ARABELLITES HAMATUS, *Grabau and Shimer*. N.A. Index Fossils, 2, 1910, p. 240, fig. 1526d.
ARABELLITES HAMATUS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 58.

Hinde's description of the species follows:

> Jaw oblong, truncate, the wide base nearly of an even width throughout, a knob-like projection in the centre of the lower basal edge, and a similar one at the end; the anterior tooth relatively wide and openly curved. On the upper straight edge are ten subequal rounded teeth. Length ⅝ line.

ARABELLITES CORNUTUS, *Hinde*

Plate V, Figures 13, 14 and 15.

ARABELLITES CORNUTUS, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 377, pl. 18, figs. 13-15.
ARABELLITES CORNUTUS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 57.

Hinde describes the species:

Jaw relatively wide, truncate, the lower basal edge curved, with a more or less prominent knob-like elevation in the centre, which is the widest part of the base, the upper edge nearly straight, with a deep furrow just below the teeth extending from the middle to the posterior extremity, beneath which a rounded elevation is sometimes present. In front is an extremely large curved hook, and on the nearly straight upper edge is a series of small teeth, from eleven to twenty in number; those towards the front are conical, whilst further back they gradually diminish in size and become rounded. Fig. 13 is one line long and ⅜ line wide; fig. 14 is 1½ line long and ½ line wide; and fig. 15 is 3 lines long and 1 line wide.

ARABELLITES CUSPIDATUS, *Hinde*

Plate V, Figure 19.

ARABELLITES CUSPIDATUS, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 378, pl. 18, fig. 19.
ARABELLITES CUSPIDATUS, *Grabau and Shimer*. N.A. Index Fossils, 2, 1910, p. 241, fig. 1527a.
ARABELLITES CUSPIDATUS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 57.

Hinde gives the following description of the species:

Jaw oblong, truncate, flattened, with an elongated depression in the upper posterior portion, the lower and upper borders nearly straight and parallel; in front a stout blunted tooth or hook, which is nearly at right angles with the main portion of the jaw, and on the upper edge about eighteen rounded minute teeth. Length 2½ lines, width ¾ line.

ARABELLITES OVALIS, *Hinde*

Plate V, Figure 16.

ARABELLITES OVALIS, *Hinde. Quart.* Jour. Geol. Soc. London, 35, 1879, p. 378, pl. 18, fig. 16.
ARABELLITES OVALIS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 58.

The following description is given by Hinde:

Main portion of jaw of an oval figure, with a very large, curved, and slightly twisted hook in front, and eight or nine small pointed teeth. Total length 1½ line, width ⅜ line.

ARABELLITES GIBBOSUS, *Hinde*

Plate V, Figure 21.

ARABELLITES GIBBOSUS, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 378, pl. 18, fig. 21.
ARABELLITES GIBBOSUS, *Grabau and Shimer*. N.A. Index Fossils, 2, 1910, p. 241, fig. 1527c.
ARABELLITES GIBBOSUS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 58.

The species is described by Hinde as follows:

Jaw oval and strongly convex, with a well-marked curved line extending from the base of the hook to the extremity; in front is a short, slightly curved, very stout hook; on the main portion of the jaw are ten subequal, oblique, pointed teeth. Length 1⅝ line, width ½ line.

ARABELLITES ASCIALIS, *Hinde*

Plate V, Figure 17.

ARABELLITES ASCIALIS, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 378, pl. 18, fig. 17.
ARABELLITES ASCIALIS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 57.

Hinde describes the species as follows:

Jaw narrow, elongated, and tapering to a point; a very long, curved, anterior tooth, not in the same plane with the body of the jaw; on the straight upper edge there are about seven minute acutely pointed teeth. Length 1 line, width 1/6 line.

Arabellites rectus, *Hinde*

Plate V, Figure 18.

Arabellites rectus, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 378, pl. 18, fig. 18.
Arabellites rectus, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 58.

Hinde gives the following description of the species:

Main portion of jaw somewhat triangular, widest in front, and gradually tapering to the blunted extremity; in front a very large and robust hook, with a deep longitudinal furrow near the outer side. Six teeth are visible on the upper edge of the jaw. Length 3½ lines, width ¾ lines.

Arabellites lunatus, *Hinde*

Plate VI, Figures 4, 5 and 6.

Arabellites lunatus, *Hinde*. Quar. Jour. Geol. Soc. London, 35, 1879, p. 378, pl. 19, figs. 4-6.
Arabellites lunatus, *Grabau and Shimer*. N.A. Index Fossils, 2, 1910, p. 241, fig. 1528d.
Arabellites lunatus, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 58.

The description by Hinde follows:

Jaw sickle or crescent-shaped, one end pointed, the other extended into a rodlike prolongation, the front surface concave. On the curved outer rim of the crescent are from ten to twelve short rounded teeth, the two anterior ones are generally slightly larger and somewhat divergent from the others; in one instance, however, these anterior teeth are not present. In fig. 4 the length of the toothed portion is 1 line, and of the projection ¾ line; fig. 5 is 1½ line in length; and fig. 6 is ⅞ line.

This is a very abundant form, and shows a good deal of variation in different examples.

Arabellites cristatus, *Hinde*

Plate VI, Figure 7.

Arabellites cristatus, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 378, pl. 19, fig. 7.
Arabellites cristatus, *Grabau and Shimer*. N.A. Index Fossils, 2, 1910, p. 241, fig. 1528g.
Eunicites cristatus, *Miller*. N.A. Geol. Pal., 1889, p. 518. (gen. ref.).
Arabellites cristatus, *Bassler*. U.S. Nat. Mus., Bull. 92, 1815, p. 57.

The description by Hinde follows:

Jaw crescentiform, with but a short angular projection, the front edge curved upwards, surface concave; on the upper border are eleven distinct elevated teeth, the first two of which are smaller and not in plane with the others. Length ¾ line.

Arabellites cervicornis, *Hinde*

Plate VI, Figures 8 and 12.

Arabellites cervicornis, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 379, pl. 19, figs. 8, 12.
Arabellites cervicornis, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 57.

The species is described by Hinde as follows:

Jaws very variable in form, sometimes crescentiform, with a short angular extension in front, at other times elongated and extended below the middle of the jaw; in front there are from two to three relatively large divergent teeth, followed by a series of from four to seven minute acute teeth. Length ⅝ line.

Arabellites pectinatus, *Hinde*

Plate VI, Figure 11.

Arabellites pectinatus, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 379, pl. 19. fig. 11.
Arabellites pectinatus, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 58.

Hinde describes the species as follows:

Jaw rudely triangular, the front portion rounded, pointed posteriorly, the sides meet below to form a short blunted extension nearly below the centre of the jaw; the upper border slightly arched, and carrying about fifteen small teeth, those in front rounded and upright, the others acute and directed backwards. Length ⅝ line.

Arabellites crenulatus, *Hinde*

Plate VI, Figure 9.

Arabellites crenulatus, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 379, pl. 19, fig. 9.
Arabellites crenulatus, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 57.

The species is described thus by Hinde:

Main portion of jaw nearly straight, flattened, and gradually tapering; in front is a short blunted rod-like extension at right angles to the toothed part of the jaw, which carries eight stout teeth, the first of which is small and claw-shaped, the others triangular and acute. Length ¾ line. Abundant.

Arabellites quadratus, *Hinde*

Plate VI, Figure 14.

Arabellites quadratus, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 379, pl. 19, fig. 14.
Arabellites quadratus, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 58.

Hinde gives the following description of the species:

Jaw composed of a nearly square, slightly convex plate, with a blunted rod-like appendage projecting obliquely from one of the lower angles; on the upper, nearly straight, edge of the plate is a series of about fifteen small, subequal, rounded teeth or crenulations, whilst just below the upper edge, on what appears to be the posterior side, there is a small spur-like tooth projecting obliquely. Length of the toothed edge ¾ line.

Arabellites scutellatus, *Hinde*

Plate VI, Figure 16.

Arabellites scutellatus, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 379, pl. 19, fig. 16.
Arabellites scutellatus, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 58.

The following description is given by Hinde:

Upper portion of the jaw subquadrate, with a prolonged, gradually narrowing base; surface slightly convex, with a very prominent protuberance at the lower posterior angle; the nearly straight upper border carries eleven teeth, of which the first is pointed, somewhat longer than the rest, and projects outwards; the others are subequal rounded teeth. Length and width each about ½ line. Abundant.

Arabellites? obliquus, *Hinde*

Plate VI, Figure 15.

Arabellites? obliquus, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 379, pl. 19, fig. 15.
Arabellites? obliquus, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 58.

Hinde describes the species as follows:

Jaw composed of a comparatively thick, obliquely semioval, concave plate; the lower rounded edge is slightly elevated, the straight upper border has about fifteen small rounded subequal teeth or crenulations. Length ⅞ line, width ½ line.

Genus LUMBRICONEREITES, *Ehlers*

Lumbriconereites, *Ehlers*. Palaeontographica, 17, 1868, p. 159.
Lumbriconereites, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 380.
Lumbriconereites, *Zittel*. Handb. Pal., 1, 1880, p. 566.
Lumbriconereites, *Miller*. N.A. Geol. Pal., 1889, p. 518.
Lumbriconereites, *Grabau and Shimer*. N.A. Index Fossils, 2, 1910, p. 242.
Lumbriconereites, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 769.

The genus is described by Hinde as follows:

> Ehlers based this genus on the resemblance of some fossil Annelids in the Solenhofen shales to those of the existing genus *Lumbriconereis*. In his specimens only the jaws appear to have been recognizable, whilst my own examples, which I propose to place under this genus, resemble the principal jaw-plate in the upper jaw; but possess a well-defined basal flange or extension.

LUMBRICONEREITES DACTYLODUS, *Hinde*

Plate VI, Figure 20.

LUMBRICONEREITES DACTYLODUS, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 380, pl. 18, fig. 20.
LUMBRICONEREITES DACTYLODUS, *Grabau and Shimer*. N.A. Index Fossils, 2, 1910, p. 242, fig. 1527b.
LUMBRICONEREITES DACTYLODUS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 770.

The species is described by Hinde as follows:

> Jaw oblong, straight, and nearly of uniform width, in the central portion a well-marked protuberance; at the front end are four curved rounded teeth bent upwards and inwards, whilst on a slightly elevated ridge, which springs obliquely from the basal flange, is a series of eighteen small rounded teeth. Length nearly 2½ lines, width ¾ line.

Genus GLYCERITES, *Hinde*

GLYCERITES, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 380.
GLYCERITES, *Miller*. N.A. Geol. Pal., 1889, p. 518.
GLYCERITES, *Grabau and Shimer*. N.A. Index Fossils, 2, 1910, p. 243.
GLYCERITES, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 552.

The genus is described by Hinde as follows:

> Jaws consisting of a simple curved hook with a side base, without smaller teeth, resembling those of the existing genus *Glycera*.

GLYCERITES SULCATUS, *Hinde*

Plate VI, Figure 1.

GLYCERITES SULCATUS, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 380, pl. 19, fig. 1.
GLYCERITES SULCATUS, *Grabau and Shimer*. N.A. Index Fossils, 2, 1910, p. 243, fig. 1528a.
GLYCERITES SULCATUS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 552.

Hinde's description follows:

> Jaw oblong, relatively wide and convex, obliquely truncate; from the truncated end a deep longitudinal furrow extends nearly to the front, where it opens into a cavity which extends below the hook; this is stout, slightly curved and somewhat bent inwards; Length 1¼ line, nearly ½ line in width.

GLYCERITES SULCATUS EXCAVATUS, *Hinde*

Plate VI, Figure 10.

GLYCERITES SULCATUS, *var.* EXCAVATUS, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 380, pl. 19, fig. 10.
GLYCERITES SULCATUS EXCAVATUS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 552.

The variety is described by Hinde as follows:

> The hooked portion in this jaw closely resembles that just described, but the posterior end is relatively wider and hollowed out, and instead of the central furrow there is a deep groove which extends round the inner edge of the main portion of the jaw. Length 1 line, width ½ line.

APPENDIX TO ERRANTIA – CONODONTS

Certain minute denticles, known as *Conodonts*, are met with in the rocks at Toronto. They are frequently referred to as the teeth of Cyclostomes, but their affinities are quite uncertain. For convenience, therefore, we have placed them as an appendix to the *Errantia*.

Genus DREPANODUS, *Pander*

Drepanodus, *Pander*. Mon. d. foss. Fische Sil. Syst., 1856, p. 20.
Drepanodus, *Miller*. N.A. Geol. Pal., 1889, p. 518.
Drepanodus, *Grabau and Shimer*. N.A. Index Fossils, 2, 1910, p. 245.
Drepanodus, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 463.

Grabau and Shimer describe the genus as follows:

Single, straight or curved teeth of more or less circular or elliptical section.

Drepanodus arcuatus, *Pander*

Plate VI, Figures 21 and 22.

Drepanodus arcuatus, *Pander*. Mon. foss. Fish. Sil. Syst., 1856, p. 20, tab. 1, figs. 2, 4, 5.
Drepanodus arcuatus, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 357, pl. 15, figs. 7, 8.
Drepanodus arcuatus, *Grabau and Shimer*. N.A. Index Fossils, 2, 1910, p. 245, fig. 1537, d, e.
Drepanodus arcuatus, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 463.

Hinde gives the following specific description:

Tooth simple, resembling a more or less curved spine, nearly circular in section, the basal portion expanded and with a slight contraction between it and the shaft of the tooth. The teeth are all translucent and of a reddish horn-color; they vary in length from ¾ line to 1⅛ line, and in width at the base from ¼ line to ⅜ line.

Genus DISTACODUS, *Hinde*

Machairodus, *Pander*. Mon. Foss. Fische Sil. Syst., 1856, p. 23.
Distacodus, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 357.
Distacodus, *Miller*. N.A. Geol. Pal., 1889, p. 518.
Distacodus, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 460.

Distacodus incurvus, (*Pander*)

Plate VI, Figure 23.

Machairodus incurvus, *Pander*. Mon. Foss. Fische Sil. Syst., 1856, p. 23, tab. 1, fig. 22.
Distacodus incurvus, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 357, pl. 15, fig. 9.
Distacodus incurvus, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 460.

Hinde describes the species as follows:

Base of tooth expanded, the shaft slightly curved, the point compressed and acute; a very strongly marked broad and sharp edge on the outer curve, and a similarly sharp, but narrower edge on the inner curve of the tooth; the central portion convex in section. Length 1¼ line, width of base ½ line.

Genus PRIONIODUS, *Pander*

Prioniodus, *Pander*. Mon. d. foss. Fische Sil. Syst., 1856, p. 28.
Prioniodus, *Miller*. N.A. Geol. Pal., 1889, p. 520.
Prioniodus, *Grabau*. Bull. Buffalo Soc. Nat. Sci., 6, 1889, p. 150.
Prioniodus, *Grabau and Shimer*. N.A. Index Fossils, 2, 1910, p. 244.
Prioniodus, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 1034.

The following generic description is given by Grabau and Shimer:

Jaw with narrow basal portion, supporting numerous delicate denticles, and an elongated tapering tooth which extends below the basal portion.

Prioniodus elegans, *Pander*

Plate VI, Figure 24.

Prioniodus elegans, *Pander*. Mon. Foss. Fische Sil. Syst., 1856, p. 29, pl. 2, figs. 22, 23.
Prioniodus elegans, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 358, pl. 15, fig. 10.
Prioniodus elegans, *Grabau and Shimer*. N.A. Index Fossils, 2, 1910, p. 244, fig. 1538d.
Prioniodus elegans, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 1034.

Hinde's description of this species follows:

Basal portion straight and narrow; at the anterior extremity is an elongated tapering main tooth, the lower portion of which appears to extend below the front part of the base. On the base are thirteen straight, delicate, pointed denticles nearly uniform in size. Both main tooth and denticles convex in section. Length of main tooth ⅝ line, of the horizontal base ⅝ line.

PRIONIODUS? POLITUS, *Hinde*

Plate VI, Figures 26 and 27.

PRIONIODUS? POLITUS, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 358, pl. 15, fig. 13.
PRIONIODUS? POLITUS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 1034.

The following description is given by Hinde:

Basal portion of tooth compressed, uneven in width, straight or slightly curved; at or near the central part a short robust main tooth with a series of short compressed denticles, varying from five to eight in number, on either side of it. Length of base from ½ line to ¾ line. The specimens have a bright polished appearance and a light horny tint.

PRIONIODUS FURCATUS, *Hinde*

Plate VI, Figure 25.

PRIONIODUS FURCATUS, *Hinde*. Quart. Jour. Geol. Soc. London, 35, 1879, p. 358, pl. 15, fig. 13.
PRIONIODUS FURCATUS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 1034.

Hinde gives the following specific description:

Base narrow and strongly arched, at the centre of the arch a prominent robust main tooth, slightly curved, depressed convex, and with sharp edges, the lower extremity blunted and produced beyond the base. On one side of the central tooth the base carries six flattened denticles inclined to the centre; on the other side are eight similar denticles, but vertical to the base. Length of main tooth ⅜ line; distance between the extremities of the base ⅝ line.

Order TUBICOLA

Genus CORNULITES, *Schlotheim*

CORNULITES, *Hall*. Pal. New York, 5, pa. 2, 1879, p. 164.
CORNULITES, *Schlotheim*. Petrefaktenkund, 1820, p. 378.
CORNULITES, *Zittel and Eastman*. Textb. Pal., 2nd Ed., 1913, p. 139.
CORNULITES, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 277. (*See* for full bibliography).

The definition of this genus as given by Zittel (*op. cit.*) follows:

Thick-walled, trumpet-shaped tubes, closed at the lower end, and sometimes attaining a length of three or four inches. Exterior annulated, and covered with very fine longitudinal striae.

CORNULITES *cf.* STERLINGENSIS (*Meek and Worthen*)

Plate II, Figures 5 and 6.

TENTACULITES STERLINGENSIS, *Meek and Worthen*. Geol. Surv. Illinois, 3, 1868, p. 343, pl. 4, fig. 8.
TENTACULITES STERLINGENSIS, *Hall*. Pal. New York, 7, Sup., 1888, p. 17, pl. 115, figs. 5-7, 32.
TENTACULITES STERLINGENSIS, *Bassler*. U.S. Nat. Mus., Bull. 92, 1915, p. 280.

The description by Meek and Worthen follows:

Shell small, slightly arched, and gradually tapering to a point; section circular; annulations prominent, angular, rising abruptly from the surface, usually about their own breadth apart; constrictions between the annulations, with fine, sharply elevated, longitudinal striae, which are not continued upon the rings.

Length, 0.56 inch; breadth at the larger end, 0.08 inch; annulations five in the space of one-eighth of an inch, at the larger end, and nine or ten in the same space at the smaller end. Longitudinal striae, five in the space of 0.02 inch.

Our rocks contain a single species of *Cornulites,* the determination of which is attended with some difficulties. The form has been referred to *C. flexuosus, C. tenuistriatus,* and *C. sterlingensis.*

Our specimens are straight or slightly curved and as far as observed do not exceed 9.5 mm. in length. Specimens of this size vary from 1.5 to 2.5 mm. in diameter at the larger end. In this total length are about 26 annulations, nearer together at the small end (.2 mm.) and more widely spaced at the larger end (.3 mm.). These annulations are rather sharp and are separated by regularly concave depressions. Fine longitudinal lines traverse the depressions, but do not seem to pass over the summits of the annulations.

Cornulites flexuosus was described by Hall from strata of Trenton age. His description and figures indicate a rather curved form with more strongly curved tip, increasing rather rapidly in diameter, and with the longitudinal striae continuous over the annulations. Later Hall ascribed to the same species a form found in the Lockport limestone: this is evidently not a member of the genus, a fact which has been recognized by many later authorities. *C. flexuosus* is recognized by Cumings from the upper part of the Utica in Indiana. His figure indicates a form 60 mm. long and 20 mm. wide at the large end.

The annulations are sharp with concave intervals and occur at the middle of the drawing at intervals of about .5 mm. The longitudinal striae seem to be continuous over the annulations. Cumings further remarks that this form is probably identical with *C. conicus,* Nicholson. Bassler, however, lists *C. conicus* as a distinct species. A comparison of our form with the figures of *C. conicus* given in the supplement to Vol. V, Pt. 2 of the Paleontology of New York, leaves no doubt as to the distinctness of the two forms.

Compared with Hall's original figures or with that given by Cumings, it is at once apparent that our form is very much finer in the annulations and differs also in that the longitudinal striae do not pass over the annulations. Our shells are also much more gradually tapering.

Cornulites tenuistriatus has been listed as occurring in the rocks at Toronto, but it does not seem possible to ascribe to that species any specimens in the museum. *C. tenuistriatus* is a much larger form with the annulations near the aperture 2.5 mm. apart. This spacing is so much greater than in our specimens that it is difficult to believe that Nicholson could have mistaken such specimens as ours for *C. tenuistriatus.*

Our specimens approach most closely to *Cornulites sterlingensis* which they resemble in size, in spacing of the annulations and of the longitudinal striae. The figure given by Meek and Worthen seems to show that the annulations are more rounded than in the Toronto forms but the figures given by Hall in the Supplement to Vol. V of the Paleontology of New York agree almost exactly. *C. sterlingensis* has hitherto been regarded as a Richmond fossil; if the Toronto form is identical the range of the species is greatly extended for it occurs practically through the whole series at Toronto and is also common in the Workman Brook section of the Lorraine at Meaford.

Locality.—Near water level, Humber river, ½ mile below Weston.
No. 1214 H.R., Royal Ontario Museum of Paleontology.

INDEX, PART IX

PAGE
Acmeidæ 2
Actinoceratidæ 19
Actinoceras 19
Actinoceras crebriseptum 20
Actinoceras *cf.* clouei 27
Arabellites 31
Arabellites ascialis 32
Arabellites cervicornis 33
Arabellites cornutus 32
Arabellites crenulatus 34
Arabellites cristatus 33
Arabellites cuspidatus 32
Arabellites gibbosus 32
Arabellites hamatus 31
Arabellites lunatus 33
Arabellites obliquus 34
Arabellites ovalis 32
Arabellites pectinatus 33
Arabellites quadratus 34
Arabellites rectus 33
Arabellites scutellatus 34
Archinacella 2
Archinacella patelliformis 2
Archinacella pulaskiensis 2
Aspidobranchia 2
Bactrites gracilis 22
Bactrites subconicus 22
Bellerophon 4
Cameroceras 14
Cephalopoda 2, 14
Clathrospira 5
Clathrospira subconica 5
Conodonts 35
Conularia 13
Conularia formosa 13
Conulariida 13
Conulariidæ 13
Cornulites 37
Cornulites *cf.* sterlingensis 37, 38
Cyclonema 11
Cyclonema bilix 11
Cyclonema *sp. indet.* 12
Cyrtolites 3
Cyrtolites ornatus 3
Cyrtolitidæ 3
Distacodus 36
Distacodus incurvus 36
Drepanodus 36
Drepanodus arcuatus 36
Endoceras 14
Endoceras proteiforme 14, 15
Endoceratidæ 14
Eotomaria 5
Errantia 28
Eunicites 28
Eunicites contortus 29
Eunicites (?) digitatus 29
Eunicites gracilis 29

PAGE
Eunicites major 28
Eunicites perdentatus 29
Eunicites simplex 29
Eunicites varians 28
Gastropoda 2
Glycerites 35
Glycerites sulcatus 35
Glycerites slucatus excavatus 35
Holochoanites 14
Hormotoma 6
Hormotoma gracilis 6
Liospira 7
Liospira helena 7
Liospira progne 7
Liospira vitruvia 7
Lophospira 8
Lophospira beatrice 8
Lophospira beatrice parva 10
Lophospira bowdeni 9
Lophospira multigruma 11
Lophospira perangulata 9
Lophospira tropidophora 10
Lumbriconereites 34
Lumbriconereites dactylodus 35
Mullusca 2
Murchisonia 6, 8
Nautiloidea 14
Nereidavus 28
Oenonites 30
Oenonites (?) carinatus 31
Oenonites cuneatus 31
Oenonites curvidens 30
Oenonites inæqualis 30
Oenonites rostratus 30
Oenonites serratus 30
Orthoceras 16
Orthoceras duseri 16
Orthoceras lamellosum 18
Orthoceras mohri 23
Orthoceratidæ 16
Palæschara beani 17
Pleurotomariidæ 5
Pleurotomaria 7, 8
Prioniodus 36
Prioniodus elegans 36
Prioniodus furcatus 37
Prioniodus (?) politus 37
Protowarthia 4
Raphistoma 7
Sinuites 4
Sinuites cancellatus 5
Sinuitidæ 4
Trochonema 12
Trochonema umbillicatum 12
Trochonematidæ 11
Tubicola 37
Vermes 2, 28

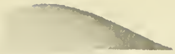
EXPLANATION OF PLATE I

Unless otherwise indicated, figures are of natural size.

	Fossil	Number	Locality	Page
Fig. 1.	*Archinacella pulaskiensis* × 1.5	1211 H.R.	Don brickyard	2
Fig. 2.	*Archinacella pulaskiensis* × 1.5	1211 H.R.	Don brickyard	2
Fig. 3.	*Cyrtolites ornatus*	1208 H.R.	Humbervale quarry	3
Fig. 4.	*Cyrtolites ornatus*	1209 H.R.	Don brickyard	3
Fig. 5.	*Cyrtolites ornatus* × 10	1209 H.R.	“ “	3
Fig. 6.	*Sinuites cancellatus*	After Ulrich and Scofield	....	5
Fig. 7.	*Sinuites cancellatus*	“ “	....	5
Fig. 8.	*Sinuites cancellatus*	“ “	....	5
Fig. 9.	*Clathrospira subconica*	292 T.	Toronto drift	5
Fig. 10.	*Hormotoma gracilis*	1213 H.R.	Don brickyard	6
Fig. 11.	*Liospira helena*	1202 H.R.	Etobicoke river	7
Fig. 12.	*Liospira helena*	After Billings		7
Fig. 13.	*Lophospira beatrice*	1197 H.R.	Humber river	8
Fig. 14.	*Lophospira beatrice parva*	1199 H.R.	Don brickyard	10
Fig. 15.	*Lophospira tropidophora*	1206 H.R.	Humbervale quarry	10
Fig. 16.	*Lophospira tropidophora*	1236 H.R.	Humbervale quarry	10
Fig. 17.	*Cyclonema bilix*	1212 H.R.	Weston	11
Fig. 18.	*Cyclonema sp. indet*	1218 H.R.	Don brickyard	12
Fig. 19.	*Trochonema umbillicatum*	After Ulrich and Scofield	....	12

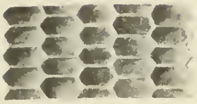
Plate I

1


2

3

4


5

6

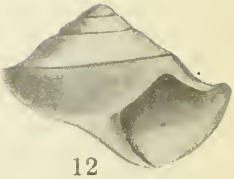
7

8

9

10

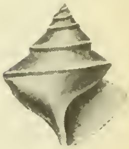
11


12

13

14

15


16

17

18

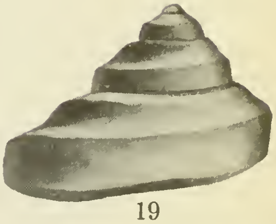
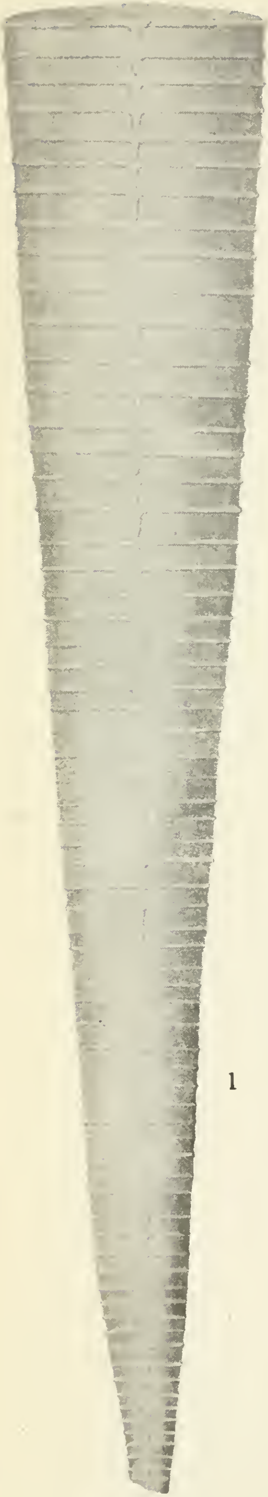
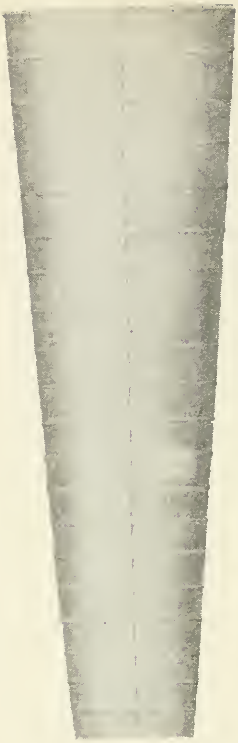
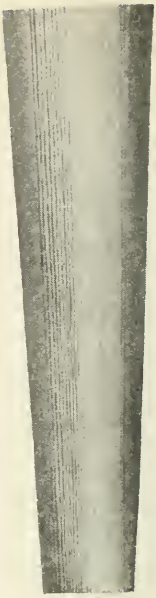
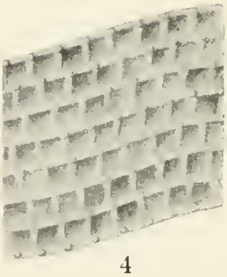

19

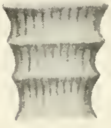
Plate II


1

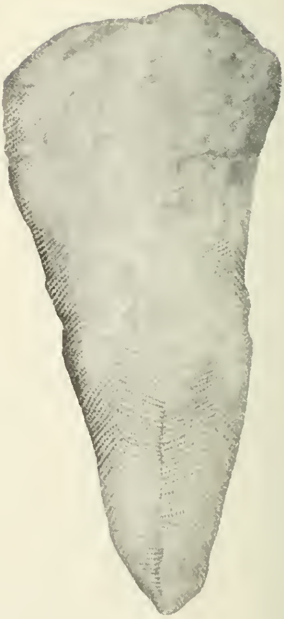

2


3


4


5

6


7

EXPLANATION OF PLATE II

Unless otherwise indicated, figures are of natural size.

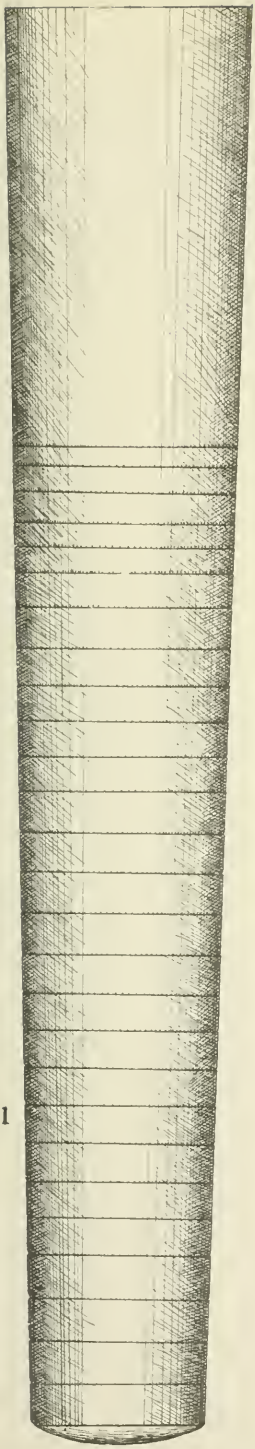
	FOSSIL	NUMBER	LOCALITY	PAGE
Fig. 1.	*Orthoceras duseri*	After Hall and Whitfield		16
Fig. 2.	*Actinoceras crebriseptum*	1226 H.R.	Prison Farm quarry	20
Fig. 3.	*Actinoceras crebriseptum*	1225 H.R.	Prison Farm quarry	20
Fig. 4.	*Conularia formosa* × 10	1216 H.R.	Don brickyard	13
Fig. 5.	*Cornulites cf. sterlingensis* × 10	1214 H.R.	Weston	37
Fig. 6.	*Cornulites cf. sterlingensis* × 10	1214 H.R.	"	37
Fig. 7.	*Conularia formosa*	After Miller and Dyer		13

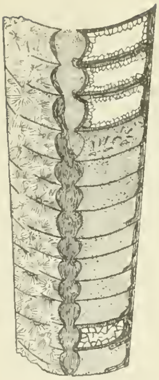
EXPLANATION OF PLATE III

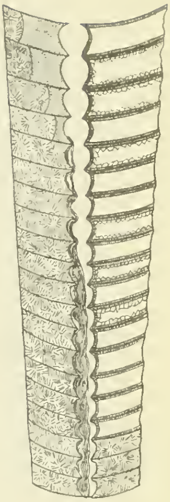
All figures are of natural size.

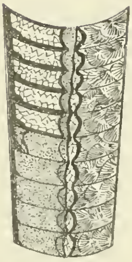
	FOSSIL	NUMBER	LOCALITY	PAGE
Fig. 1.	*Actineroceras crebriseptum.* Specimen showing body chamber	941 H.R.	Humber river	26
Fig. 2.	*Actinoceras crebriseptum.* Shows siphuncular thickenings, clay filling (dotted), fibrous layer, secondary calcite with disrupted septa on left, open camerae with later calcite on right, also the continuation of the secondary calcite as a thin layer on right	1219 H.R.	Prison Farm quarry	24
Fig. 3.	*Actinoceras crebriseptum.* Similar to Fig. 2 but the antisiphonal side is weathered and consequently the secondary calcite layer and the fibrous layer are absent	1221 H.R.	" "	26
Fig. 4.	*Actinoceras crebriseptum.* Similar to Fig. 2 but shows cavity within siphuncular thickenings	1225 H.R.	" "	23
Fig. 5.	*Actinoceras crebriseptum.* Transverse section showing the secondary calcite on both walls, also trace of endosiphuncle. It also shows well the formation of the fibrous layer only where clay has not filled the space	1220 H.R.	" "	20
Fig. 6.	*Actinoceras crebriseptum.* Dorso-ventral section showing well the formation of the fibrous layer which occurs over all exposed surfaces, clay as well as shell. The antisiphonal side is worn away	1226 H.R.	" "	27
Fig. 7.	*Actinoceras crebriseptum.* Transverse section showing the symmetrical way the secondary calcite occurs on the outer walls on the camerae and on the orad side of septa. No siphuncular thickenings. Secondary calcite, dotted; clay, crosses; fibrous layer, cross-lined	1229 H.R.	" "	20
Fig. 7a.	*Actinoceras crebriseptum.* Dorso-ventral section of siphonal side showing the secondary calcite. Clay, crosses	1229 H.R.	" "	24
Fig. 8.	*Actinoceras crebriseptum.* Transverse section showing the secondary calcite on both walls and trace of endosiphuncle	1230 H.R.	Humber river	23
Fig. 9.	*Actinoceras crebriseptum.* Dorso-ventral section of large fragment, probably far orad. Shows marginal siphuncle and absence of secondary calcite or siphuncular thickenings	1222 H.R.	Prison Farm quarry	26

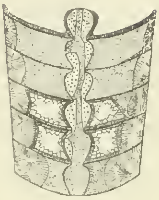
Plate III

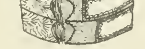

1

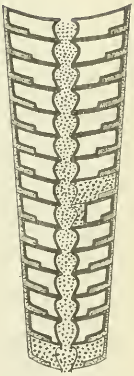

2


3

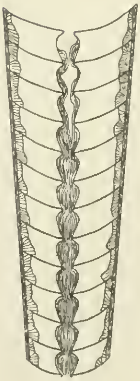

4


5


6


7

7*a*


8

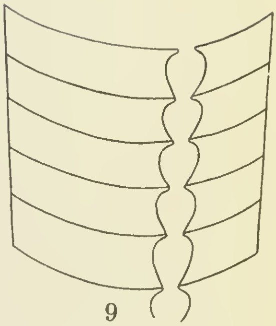
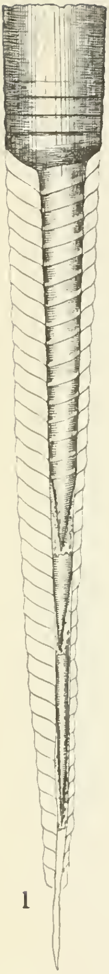
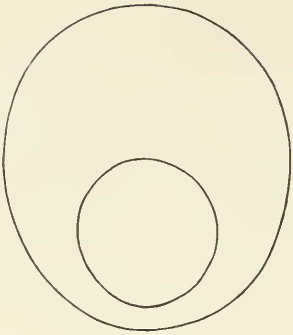
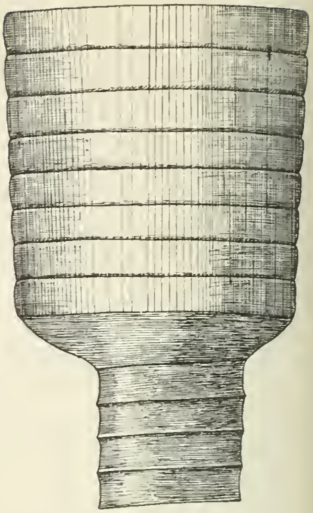
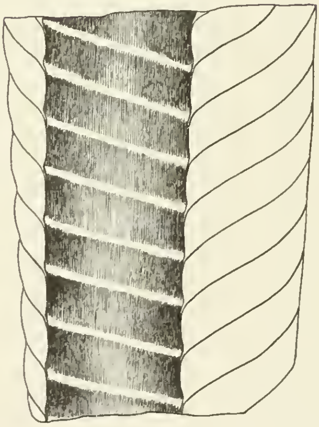

9

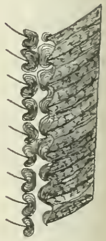
Plate IV

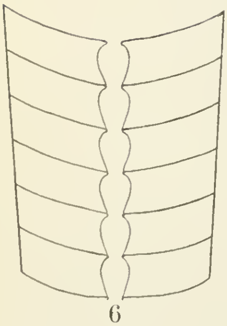

1

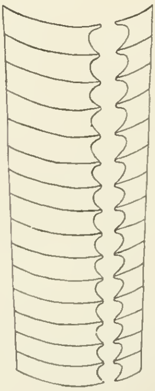

2

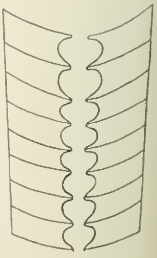

3


4


5


6


7


8

Explanation of Plate IV

Unless otherwise stated, all figures are of natural size.

	Fossil	Number	Locality	Page
Fig. 1.	*Endoceras proteiforme.* 1-12 natural size. Portion of body chamber and three camerae orad. Remaining camerae shown in dorso-ventral section. Siphuncle intact orad but broken in places exposing the endocones.......	1234 H.R.	Nottawasaga	15
Fig. 2.	*Endoceras proteiforme.* One-fourth natural size. Cross section showing size and position of siphuncle...........	952 H.R.	Collingwood	15
Fig. 3.	*Endoceras proteiforme.* One-half natural size. Average Toronto specimen....	1235 H.R.	Humber river	15
Fig. 4.	*Endoceras proteiforme.* One-fourth natural size. Shows overlapping of funnels. Siphuncle intact; camerae in section..........................	952 H.R.	Collingwood	15
Fig. 5.	*Actinoceras cf. clouei.* Vertical section.	1228 H.R.	Humbervale quarry	27
Fig. 6.	*Orthoceras lamellosum.* Transverse vertical section........................	1233 H.R.	Prison Farm quarry	18
Fig. 7.	*Orthoceras duseri.* Dorso-ventral longitudinal section....................	12093	Clarksville, Ohio	17
Fig. 8.	*Orthoceras duseri.* Transverse longitudinal section....................	1223 H.R.	Humber river	18

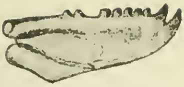
EXPLANATION OF PLATE V

Magnification of figures indicated on plate.

	FOSSIL	ORIGIN	LOCALITY	PAGE
Fig. 1.	*Eunicites major*	After Hinde	Toronto	28
Fig. 2.	*Eunicites varians*	“ “	“	28
Fig. 3.	*Eunicites varians*	“ “	“	28
Fig. 4.	*Eunicites contortus*	“ “	“	29
Fig. 5.	*Eunicites varians*	“ “	“	28
Fig. 6.	*Eunicites perdentatus*	“ “	“	29
Fig. 7.	*Oenonites curvidens*	“ “	“	30
Fig. 8.	*Oenonites inaequalis*	“ “	“	30
Fig. 9.	*Oenonites serratus*	“ “	“	30
Fig. 10.	*Oenonites rostratus*	“ “	“	30
Fig. 11.	*Oenonites cuneatus*	“ “	“	31
Fig. 12.	*Arabellites hamatus*	“ “	“	31
Fig. 13.	*Arabellites cornutus*	“ “	“	32
Fig. 14.	*Arabellites cornutus*	“ “	“	32
Fig. 15.	*Arabellites cornutus*	“ “	“	32
Fig. 16.	*Arabellites ovalis*	“ “	“	32
Fig. 17.	*Arabellites ascialis*	“ “	“	32
Fig. 18.	*Arabellites rectus*	“ “	“	33
Fig. 19.	*Arabellites cuspidatus*	“ “	“	32
Fig. 20.	*Lumbriconereites dactylodus*	“ “	“	35
Fig. 21.	*Arabellites gibbosus*	“ “	“	32

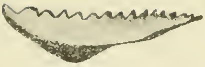
Plate V

1



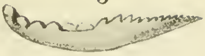
×3

2



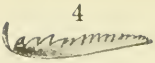
×6

3



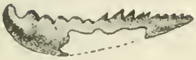
×6

4



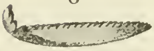
×8

5



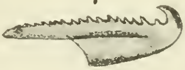
×3½

6



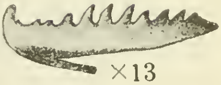
×15

7



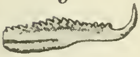
×15

8



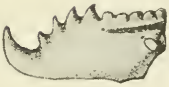
×13

9



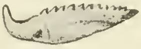
×12

10



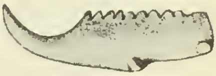
×15

11



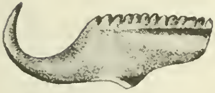
×16

12



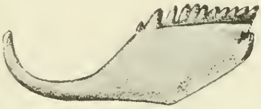
×20

13



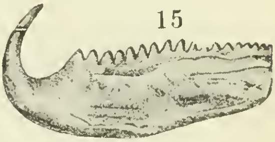
×12

14



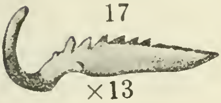
×10

15



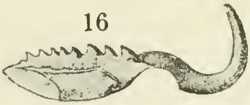
×5

17



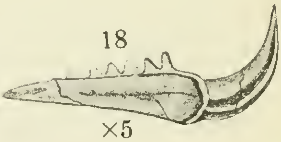
×13

16



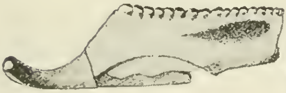
×10

18



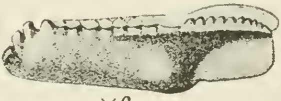
×5

19



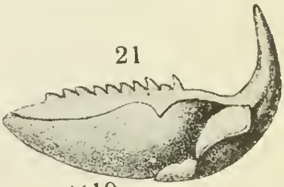
×7

20



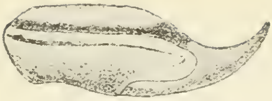
×6

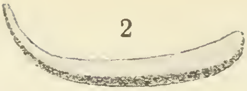
21

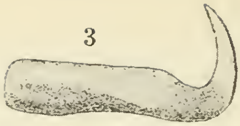


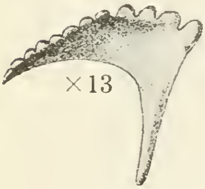
×10

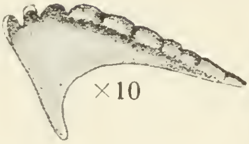
Plate VI

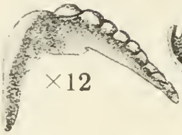
1

×13

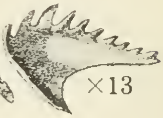
2

×13

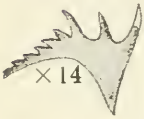
3

×14

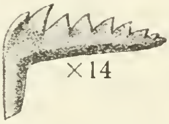
4

×13

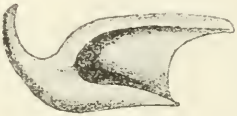
5

×10

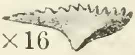
6

×12

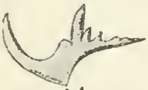
7

×13

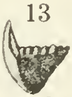
8

×14

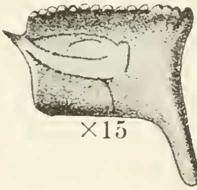
9

×14

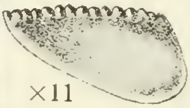
10

×15

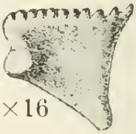
11

×16

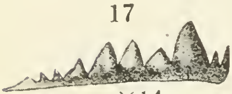
12

×14

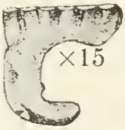
13

×12

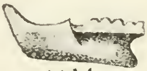
14

×15

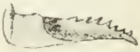
15

×11

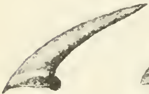
16

×16

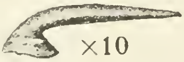
17

×14

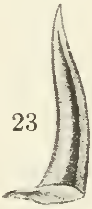
20

×15

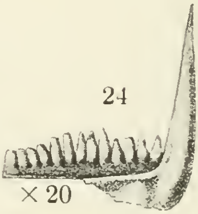
19

×14

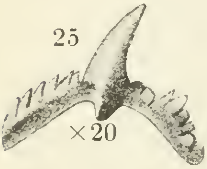
18

×12

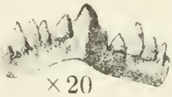
21

×10

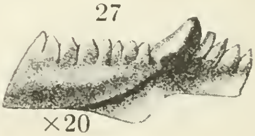
22

×10

23

×10

24

×20

25

×20

26

×20

27

×20

EXPLANATION OF PLATE VI

Magnification of figures indicated on plate.

	FOSSIL	ORIGIN	LOCALITY	PAGE
Fig. 1.	*Glycerites sulcatus*	After Hinde	Toronto	35
Fig. 2.	*Eunicites simplex*	" "	"	29
Fig. 3.	*Eunicites gracilis*	" "	"	29
Fig. 4.	*Arabellites lunatus*	" "	"	33
Fig. 5.	*Arabellites lunatus*	" "	"	33
Fig. 6.	*Arabellites lunatus*	" "	"	33
Fig. 7.	*Arabellites cristatus*	" "	"	33
Fig. 8.	*Arabellites cervicornis*	" "	"	33
Fig. 9.	*Arabellites crenulatus*	" "	"	34
Fig. 10.	*Glycerites sulcatus excavatus*	" "	"	35
Fig. 11.	*Arabellites pectinatus*	" "	"	33
Fig. 12.	*Arabellites cervicornis*	" "	"	33
Fig. 13.	*Eunicites (?) digitatus*	" "	"	29
Fig. 14.	*Arabellites quadratus*	" "	"	34
Fig. 15.	*Arabellites (?) obliquus*	" "	"	34
Fig. 16.	*Arabellites scutellatus*	" "	"	34
Fig. 17.	*Sp. indet*	" "	"	
Fig. 18.	*Sp. indet*	" "	"	
Fig. 19.	*Oenonites (?) carinatus*	" "	"	31
Fig. 20.	*Sp. indet*	" "	"	
Fig. 21.	*Drepanodus arcuatus*	" "	Garrison Common	36
Fig. 22.	*Drepanodus arcuatus*	" "	" "	36
Fig. 23.	*Distacodus incurvus*	" "	" "	36
Fig. 24.	*Prioniodus elegans*	" "	" "	36
Fig. 25.	*Prioniodus (?) politus*	" "	" "	37
Fig. 26.	*Prioniodus (?) politus*	" "	" "	37
Fig. 27.	*Prioniodus furcatus*	" "	" "	37

PROVINCE OF ONTARIO
DEPARTMENT OF MINES

HON. H. MILLS, MINISTER OF MINES — THOS. W. GIBSON, DEPUTY MINISTER

THIRTY-FIRST ANNUAL REPORT

OF THE

ONTARIO DEPARTMENT OF MINES

BEING

VOL. XXXI, PART X, 1922.

CONTENTS

PAGES
Mining Accidents in Ontario, 1921 .... 1—10
Mines of Ontario .... 11—86
Instruction Classes for Prospectors .... 87—94
Notes on Clays of the Missinaibi River .... 95—96

PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY OF ONTARIO

TORONTO
Printed by CLARKSON W. JAMES, Printer to the King's Most Excellent Majesty
1923

Printed by
THE RYERSON PRESS

CONTENTS, PART X

MINING ACCIDENTS IN ONTARIO, 1921.

PAGE

- Accidents during 1921 1
- Workmen's Compensation Rates 1
- Table of Fatalities 2
- Analysis of Fatalities at Mines 2
- Table of Fatal Accidents in Mines, Metallurgical Works and Quarries, 1901 to 1921 3
- Fatalities classified according to occupation and nationality 3
- Table of Fatal Accidents in or about Mines of Ontario during 1921 4
- Table of Fatal Accidents at Metallurgical Works, 1921 4
- Table of Fatal Accidents at Quarries, Clay and Gravel Pits, 1921 4
- Fatalities at mines classified according to cause and place 6
- Non-fatal Accidents Classified according to Occupation and Nationality of Men Injured (Mines) 6
- Causes of Non-fatal Accidents (Mines) 7
- Causes of Non-Fatal Accidents (Metallurgical Works) 7
- Occupation and Nationality of Men Injured (Metallurgical Works) 8
- Occupation and Nationality of Men Injured (Quarries, Clay and Gravel Pits) 8
- Causes of Non-fatal Accidents (Quarries, Clay and Gravel Pits) 9
- Classification of Explosive Accidents 9
- Prosecutions 9
- Testing Hoisting Cables 9

MINES OF ONTARIO.

- Mines and Prospects Inspected, 1921 11
- Metallurgical Works Inspected, 1921 15
- I.—NORTHWESTERN ONTARIO 15
  - Gold 15
  - Iron 17
  - Iron Pyrites 18
  - Silver 18
- II.—SUDBURY, NORTH SHORE AND MICHIPICOTEN 20
  - Gold 20
  - Iron 21
  - Copper 22
  - Nickel and Copper 23
    - British America Nickel Corporation, Limited 24
    - International Nickel Company of Canada, Limited 24
    - Mond Nickel Company, Limited 27
  - Iron Pyrites 28
  - Miscellaneous 28
- III.—DISTRICT OF TIMISKAMING 28
  - Gold 28
    - Boston Creek, Larder Lake, etc. 28
    - Porcupine 31
    - Kirkland Lake 40
    - Matachewan 45
    - West Shiningtree 45
    - Howry Creek 46
  - Silver 47
    - Cobalt 47
    - South Lorrain 55
    - Elk Lake and Gowganda 57
- IV.—SOUTHERN AND EASTERN ONTARIO 58
  - Calcite and Dolomite 58
  - Corundum 59
  - Feldspar 59
  - Fluorspar 63
  - Gold 63
  - Graphite 64
  - Gypsum 64
  - Iron Pyrites 65
  - Lead 65
  - Mica 66
  - Molybdenite 66
  - Talc 67
  - Metallurgical Works 67
- Quarries and Other Excavations 70
  - Quarries Inspected during 1921 71
  - Clay Pits Inspected during 1921 78
  - Sand and Gravel Pits Inspected during 1921 80

INSTRUCTION CLASSES FOR PROSPECTORS.

- Introduction 87
- Methods Adopted 87
- Attendance at Classes 88
  - Madoc 89
  - Sault Ste. Marie 89
  - Port Arthur 89
  - Fort William 90
  - Sudbury 90
  - Haileybury 91
  - Swastika 91
  - Kirkland Lake 92
  - South Porcupine 92
  - Timmins 92
  - Elk Lake 93
  - North Bay 93
- General 93
- Suggestions 94

NOTES ON THE CLAYS OF THE MISSINAIBI RIVER.

- Introduction 95
- Mesozoic Clays 95

DIAGRAM AND ILLUSTRATION

- Silver Islet Mine, Diamond-drilling at the Fourth Level 19
- Mill at Keeley Silver Mine, 1921 56

MINING ACCIDENTS IN ONTARIO, 1921

By

Chief Inspector of Mines, T. F. Sutherland, Toronto; Inspectors, G. E. Cole, Ottawa; James Bartlett, Sudbury; J. G. McMillan, Cobalt; A. R. Webster, Toronto.

Accidents during 1921

	Fatal	Non-fatal	Total
Mines, underground	11	597	608
Mines, surface	1	246	247
Metallurgical Works	4	211	215
Quarries	5	...	....
Clay Pits	0	208	216
Sand and Gravel Pits	3	...	....
Total	24	1,262	1,286

During the year 1921, at the mines, metallurgical works, quarries, clay, sand and gravel pits regulated by the Mining Act of Ontario, there were 1,286 accidents reported to the Department of Mines up to January 10, 1922. Twenty-four of these accidents were fatal.

Four of the fatal accidents at quarries occurred in the handling of explosives and were due to carelessness or ignorance; of the three fatal accidents at gravel pits, two were caused by undermining and the third by material falling from a face sixteen feet in height. A knowledge of explosives and a strict observance of the Mining Amendment Act would have prevented all these accidents.

Workmen's Compensation Rates

The assessment per $100 of pay roll made by the Workmen's Compensation Board is based on the actual cost of the accidents occurring in each class during the previous year and consequently shows the accident hazard of each class. The adjusted rates for 1920 and the provisional rates for 1921 show a decrease in the silver mining industry, a slight increase in gold and nickel-copper mining, and a fifty per cent. increase in quarrying. The rate for quarries is twice that of nickel-copper mining, and three times that of silver mining. Most of the employees in quarries are English-speaking, but are unskilled in handling tools and material, have no knowledge of explosives and seldom are under skilled supervision such as prevails at mines. The Department of Mines now has an inspector who devotes all his time to the inspection of quarries, clay, sand and gravel pits in an effort to cut down the unnecessary accident hazard of this industry.

Following is a table of Workmen's Compensation rates:—

	1920 Adjusted.	1921 Provisional.
Silver mining	$2 00	$2 00
Treatment of ores, with heat, in a silver mining industry	1 00	1 00
Treatment of ores, without heat, in a silver mining industry	50	50
Gold mining	2 40	2 50
Treatment of ores, with heat, in a gold mining industry	1 20	1 25

Treatment of ores, without heat, in a gold mining industry	60	70
Nickel or nickel copper mining	3 00	3 00
Treatment of ores, with heat, in a nickel or nickel-copper mining industry	1 50	1 50
Treatment of ores, without heat, in a nickel or nickel-copper mining industry	75	75
Mining N.O.S.	2 50	2 50
Treatment of ores or minerals, with heat, in an industry in this group	1 25	1 25
Treatment of ores or minerals, without heat, in an industry in this group	70	70
Iron smelting, as a business	2 00	2 00
Treatment of ores or minerals, with heat, N.O.S., as a business	1 20	1 20
Treatment of ores or minerals, without heat, N.O.S., as a business	60	60
Refining of nickel, as a business	1 50	1 50
Sand, shale, clay or gravel pits	4 00	4 00
Quarries, as a business; stone crushing	6 00	6 00

Table of Fatalities

	1917	1918	1919	1920	1921
Mines, underground	19	11	21	15	11
Mines, surface	7	4	6	6	1
Metallurgical works	6	12	10	3	4
Quarries	4	5	2	5	8
Totals	36	32	39	29	24

By months, the fatalities occurred as follows:

January	1
February	1
March	3
April	4
May	2
June	2
July	1
August	1
September	3
October	3
November	1
December	2
Total	24

Classifying the fatalities according to the industry gives the following:

Nickel mines and smelters.	2
Iron mines and blast furnaces.	3
Iron pyrites mines.	1
Silver mines and smelters.	4
Gold mines and mills.	6
Limestone quarries.	5
Gravel pits.	3
Total.	24

Analysis of Fatalities at Mines

	1917 Per cent.	1918 Per cent.	1919 Per cent.	1920 Per cent.	1921 Per cent.
Falls of ground.	15.4	20.0	22.2	23.8	33.33
Shaft accidents.	15.4	0.0	29.6	9.5	16.66
Explosives.	15.4	40.0	7.4	23.8	16.66
Miscellaneous underground.	26.9	26.6	18.5	14.3	25.00
Surface.	26.9	13.3	22.2	28.6	8.33

Table of Fatal Accidents in Mines, Metallurgical Works and Quarries, 1901 to 1921

	Persons killed at metallurgical works and mines.	Persons employed at metallurgical works and producing mines.	Persons employed at non-producing mines (estimated).	Total persons employed	Fatal accidents per 1,000 employed.
1901	13	4,135	550	4,685	2.77
1902	10	4,426	450	4,876	2.05
1903	7	3,499	400	3,899	1.79
1904	7	3,475	400	3,875	1.80
1905	9	4,415	500	4,915	1.83
1906	11	5,017	750	5,767	1.90
1907	22	6,305	1,140	7,445	2.93
1908	47	7,435	1,750	9,185	5.11
1909	49	8,505	2,000	10,505	4.66
1910	48	10,862	2,000	12,862	3.73
1911	49	12,543	2,000	14,543	3.37
1912	43	13,108	2,000	15,108	2,84
1913	64	14,293	2,000	16,293	3.93
1914	58	14,361	1,500	15,861	3.60
1915	22	13,114	1,500	14,614	1,51
1916	51	14,624	2,000	16,624	3.07
1917	36	16,791	1,000	17,791	2.02
1918	32	14,726	500	15,226	2.10
1919	39	11,926	1,000	12,926	3.00
1920	29	10,486	1,000	11,486	2.61
1921	24	8,436	1,000	9,436	2.54

Fatalities classified according to occupation and nationality:

Occupations and nationalities of the men killed were:

Occupation.	English Speaking	Italian	Russian	Norwegian	Finn	Pole	Roumanian	Ukrainian	Total
Miner	1	2	1				1	1	6
Foreman	4			1					5
Laborer	1		1						2
Blaster	1					1			2
Teamster	2								2
Repairman	1								1
Conductor	1								1
Skiptender	1								1
Shaftman					1				1
Pipefitter		1							1
Trammer	1								1
Deckman	1								1
Total	14	3	2	1	1	1	1	1	24

Table of Fatal Accidents in or about

No.	Date	Name of Mine.	Name of Owner.	Name.	Occupation.
1	May 8	Coniagas.	Coniagas Mines, Ltd.	Arthur Walker.	Skip tender. . . .
2	Nov. 28	Dome.	Dome Mines Co., Ltd.	W. Alini.	Shaftman. . . . . .
3	Apl. 13	Hollinger.	Hollinger Consolidated Gold Mines, Ltd.	D. Racuba. . . .	Miner. . . . .
4	July 22	“	“ “	A. Janice.	Blaster. . . . .
5	Dec. 6	“	“ “	L. Spada.	Pipefitter. . . . . .
6	Mar. 10	Creighton.	International Nickel Co. of Canada.	Albert Smith. . .	Miner. . . . .
7	Dec. 12	Kirkland Lake.	Kirkland Lake Gold Mining Co., Ltd.	S. Donaldson. .	Foreman. . . . . .
8	June 9	McIntyre.	McIntyre Porcupine Mines, Ltd.	P. Cimetta. . . .	Miner. . . . .
9	Oct. 17	Buffalo.	Mining Corp. of Canada. .	H. B. Smith. . .	Trammer. . . . . .
10	Mar. 9	Victoria.	Mond Nickel Co., Ltd. . . .	G. Kramar. . . .	Miner. . . . .
11	June 8	Northpines.	Nichols Chemical Co.	H. Goluk.	Miner. . . . .
12	Apl. 27	Myer.	Nipissing Mining Co.	A. Pope.	Deckman. . . . . .

Table of Fatal Accidents at

No.	Date	Name of Works.	Name of Owner.	Name.	Occupation.
13	Mar. 24	Blast Furnace.	Algoma Steel Corporation.	Thos. E. Bell. .	Repair man. . . .
14	May 1	Slag Dump.	“ “ “	Albert Dore. . .	Conductor. . . . .
15	Feb. 7	Caste house.	Canadian Furnace Co.	A. Selick.	Labourer. . . . . .
16	Apl. 23	Smelter.	Deloro Smelting & Refining Co.	G. Tompkins. .	Labourer. . . . . .

Table of Fatal Accidents at

No.	Date.	Name of Works.	Name of Owner.	Name.	Occupation.
17	Sept. 2	Washago Quarry. . . .	Dept. Public Highways. . .	L. Campoli. . . .	Miner. . . . .
18	Oct. 21	Quarry.	Lincoln County.	L. Glendenning.	Blaster. . . . .
19	Oct. 27	Quarry.	Ontario Reformatory.	N. J. Agnew. . .	Superintendent.
20	Aug. 6	Quarry.	Standard White Lime Co. .	W. J. Culford. .	Foreman. . . . . .
21	Jan. 29	Gravel Pit.	Townsend Twp.	A. R. King. . . .	Teamster. . . . . .
22	Apl. 22	Quarry.	Woodland & Co.	W. Woodland. .	Foreman. . . . . .
23	Sept. 15	Gravel pit.	Wright & Co.	A. Nilsen.	Foreman. . . . . .
24	Sept. 16	Gravel pit.	York County.	S. Ball.	Teamster. . . . . .

Mines of Ontario during 1921.

Nationality.	Age	Married or Single	Above ground	Below ground	Cause of Accident.
English.......	50	M	......	1	Fell in shaft.
Finn..........	36	M	......	1	Fell in shaft.
Russian.......	44	M	......	1	Caught by run of ore in mill hole.
Pole..........	35	S	......	1	Walked into blast.
Italian........	34	M	......	1	Struck by box in drill chute.
English.......	31	M	......	1	Fall of ground in stope.
Canadian......	37	M	......	1	Fall of ground in stope.
Italian........	20	S	......	1	Drilled into explosive.
English.......	32	M	......	1	Fall of ground from wall of open pit.
Roumanian....	26	S	......	1	Fell from bench into stope.
Ukrainian.....	30	M	......	1	Fall of ground in crosscut.
English.......	24	S	1	......	Struck by runaway car.

Metallurgical Works, 1921.

Nationality.	Age.	Married or Single.	Cause of Accident.
Canadian.......	49	M	Crushed between engine and post.
Canadian.......	35	M	Burned by molten slag.
Russian........	40	M	Struck by cast of iron when chain broke.
Canadian.......	51	M	Electrocuted.

Quarries, Clay and Gravel Pits, 1921.

Nationality.	Age.	Married or Single.	Cause of Accident.
Italian.........	26	M	Explosion while loading holes.
Canadian.......	24	S	Picked into explosive.
Canadian.......	35	M	Struck by flying rock from explosion.
Canadian.......	34	S	Electrocuted.
Canadian.......	30	S	Bank undermined and fell.
Canadian.......	57	M	Remained too long lighting fuses.
Norwegian.....	50	M	Fall of sand threw him against wheelbarrow.
English........	35	M	Bank undermined and fell.

Ages of the men killed:

Age	17-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	Total.
No. killed.	1	2	4	8	3	1	3	1	1	24

Fatalities at mines classified according to cause and place:

Below Ground:	
Falls of ground	4
Shaft accidents	2
Explosives	2
Buried in stope	1
Fell into open stope	1
Miscellaneous	1

Above Ground:	
Struck by car	1

Non-fatal Accidents Classified According to Occupation and Nationality of Men Injured (Mines)

Mines—Surface and Underground	English Speaking	Italian	Austrian	Russian	Finn	Pole	Roumanian	Ukrainian	Bulgarian	French	Spaniard	Galician	German	Swede	Belgian	Serbian	Total
Miner	167	47	35	15	17	20	11	7	2	2	2	3		1	1		330
Trammer	44	28	21	8	6	7	12		3	3	3	1	2				138
Labourer	80	16	3	4	3	2	2	3					1				114
Mechanic	30	3	1						1								35
Chute loader	13	6	1	4		2		2									28
Mill worker	25	2															27
Timberman	15			1	5					1							22
Carpenter	17									1							18
Pipefitter	5	8			1												14
Blacksmith	7	1					1	2			2						13
Scaler	3	3		3	1		2										12
Foreman	8		1						1								10
Electrician	8																8
Deckman	7					1											8
Nipper	4	1	2		1												8
Engineer	7																7
Teamster	6									1							7
Motorman	4	2							1								7
Chute blaster	1		2	1					1			1					6
Cage tender	2		2				1										5
Crusherman	4																4
Sampler	4																4
Shaftman	1	1			1												3
Sorter	1	2															3
Trackman	1	1															2
Blaster				1												1	2
Assayer	2																2
Cook	2																2
Fireman	1																1
Furnaceman	1																1
Brakeman	1																1
Clerk	1																1
Total	472	121	68	37	35	32	29	14	9	8	7	5	3	1	1	1	843

Causes of Non-fatal Accidents (Mines)

Mines	Surface	Under-ground	Total
Working at chute		110	110
Slipped or tripped and fell	36	37	73
Crushed or hit by car or motor	10	53	63
Falling Rock		56	56
Sprain or strain	16	34	50
Foreign matter in eye	19	30	49
Struck by falling objects	25	22	47
Handling rock, scaling	7	38	45
Fingers crushed	16	24	40
Injured by hand tools	20	16	36
Rock rolling down pile	3	32	35
Infection	14	15	29
Injured by drill steel	4	23	27
Fell from elevation	11	13	24
Injured by drill		16	16
Caught by machinery	14		14
Struck by hammer	5	9	14
Struck by flying objects	5	7	12
Flesh punctured by nail	3	9	12
Burned or scalded	8	3	11
Injured by timber		11	11
Falling off ladder	1	10	11
Cut by metal, scrap, etc	8		8
Injured by cage or skip		8	8
Collapse of staging	1	6	7
Miscellaneous	5	2	7
Injured by animals	2	3	5
Injured by bar		5	5
Injured by machinery	4	1	5
Caught by belt	5		5
Injured by particles dislodged by drill		4	4
Electric burns	3		3
Poisoning	1		1
Total	246	597	843

Causes of Non-Fatal Accidents (Metallurgical Works)

Hit by falling objects	25
Slipped or tripped and fell	20
Burned or scalded	20
Foreign matter in eye	17
Fall from elevation	15
Injured by cars, ladles, etc.	13
Burned at furnace	11
Burned by slag, matte, etc.	10
Sprain	9
Caught by machinery	8
Injured by bar	8
Crushed between two objects	7
Injured by tools	7
Hit by hammer	6
Handling rock or matte	5
Internal injury carrying load	5
Hit by flying objects	4
Burned by explosion of slag or matte	3
Infection from wound	3
Poisoned	3
Injured by slag pot	3
Cut by metal, scrap, etc.	2
Stepped on nail	2
Injured by train	2
Electric burn	1
Gas asphyxiation	1
Fall from vehicle	1
	211

Occupation and Nationality of Men Injured (Metallurgical Works)

	English speaking	Italian	Austrian	Chinese	Russian	Pole	French	Roumanian	Finn	Serbian	Belgian	Galician	Ukrainian	Total
Labourer	45	32	7	2	4	4	2	1		1	2		1	101
Furnace man	11	2	1		1	1	2							18
Mechanic	11	1			1									13
Furnace helper	6	3		2				1						12
Foreman	9							1		1				11
Carpenter	6								1			1		8
Trainman	6													6
Tuyere puncher	3	1		2										6
Crane man	4		1											5
Pipefitter	4								1					5
Blacksmith	2	1												3
Weigher	3													3
Fireman	3													3
Crusherman	1			1										2
Scrapper		2												2
Cokeman	1	1												2
Teamster	2													2
Clerk	2													2
Converter man	1													1
Hoistman	1													1
Trackman		1												1
Oiler		1												1
Electrician	1													1
Trammer	1													1
Motorman					1									1
Total	123	45	9	7	7	5	4	3	2	2	2	1	1	211

Occupation and Nationality of Men Injured (Quarries, Clay and Gravel Pits)

Occupation	English speaking	Italian	Roumanian	Austrian	Russian	Ukrainian	Finn	Pole	Total
Labourer	105	24	2	1	2	2		1	713
Quarry man	12	2	1	2					17
Teamster	14								14
Shovel craneman	8	1							9
Foreman	6								6
Blacksmith	4						1		5
Fireman	4								4
Watchman	2		1						3
Brakeman	3								3
Machinist	3								3
Carpenter	3								3
Engineer	1								1
Crusherman	1								1
Electrician	1								1
Blaster	1								1
Total	168	27	4	3	2	2	1	1	208

Causes of Non-fatal Accidents (Quarries, Clay and Gravel Pits)

By material while loading at face	44
By machinery	23
By timber or hand tools	21
By haulage accidents	20
By flying pieces of rock from sledging	16
By falls or slides of rock, clay or gravel	16
By quarry cars or locomotives	14
By slipping or stumbling	10
By drilling accidents	10
By falling from hoists, derricks or ladders	9
By explosives	6
By falling from surface, benches, or face	4
By stepping on nail	4
By burns	4
By electricity	2
By other causes	5
	208

Classification of Explosive Accidents

	Non-fatal.	Fatal.
Explosion, while tamping	3	1
Drilled into explosive	2	1
Struck unexploded charge with hammer or pick	1	1
Detonators	1	....
Premature explosion	2	1
Hit by rock from explosion	1	1
Walked into blast	....	1
Explosion while shovelling	2	....
Total	12	6

Prosecutions

At Kirkland Lake, on June 10, Andrew Kakar pleaded guilty to riding on May 3 in empty cars on the cage at the Teck-Hughes Gold Mines, in violation of Rule 75, Section 164, of the Mining Act. Reeve John McLennan imposed a fine of $20.00 and costs.

Testing Hoisting Cables.

Rule 68, Section 164, of the Mining Amendment Act, 1919, being Part IX, of the Mining Act of Ontario, is as follows:

TESTING PORTION OF ROPE.

(68) At least once in every six months the hoisting rope shall have a portion not less than six feet in length cut off the lower end. With the exception of the cutting at the end of the first six months the length so cut off shall have the ends adequately fastened with binding wire to prevent the disturbance of the strands and shall be sent to a reliable testing laboratory for a breaking test. The certificate of such test shall be kept on file. This rule shall not come into effect until proclaimed by the Lieutenant-Governor in Council.

This rule was by Order in Council dated 7 December, 1921, brought into effect on 1 January, 1922, and proclamation of same was duly made in *The Ontario Gazette.*

In order to distribute the work in the testing laboratory the Department decided to make this regulation apply as follows:

In the Mining Division of Kenora, Fort Frances, Kowkash and Port Arthur, on the first day of January, 1922;

In the Mining Divisions of Sault Ste. Marie, Sudbury and Parry Sound, on the first day of February, 1922;

In the Mining Divisions of Temiskaming, Coleman, Montreal River and Gowganda, on the first day of March, 1922;

In the Porcupine Mining Division, on the first day of April, 1922;

In the Larder Lake Mining Division, on the first day of May, 1922;

And in all other parts of the Province, on the first day of June, 1922.

The requirements as to the portion of cable for testing purposes are as follows:

The portion of cable sent to the testing laboratory shall be the six feet above the socket or clamps. This test piece shall be kept free from bends and shall be shipped in a box, or attached by staples to a two-inch board, six feet six inches in length. The ends shall be wrapped in burlap to prevent injury to persons in handling. Before cutting, at least two seizings or servings of soft iron wire, each about one and a half inches long, shall be placed tightly upon the rope at a distance apart equal to the length of the test specimen (72 inches). If the ends of wire rope are not properly secured, the relation of tensions in the rope will be disturbed; hence it is most important that proper seizings be placed at each side of any point at which the rope is to be cut, and, if possible, two or three seizings should be employed at each side of a cut. Annealed iron wire should be used, the suitable sizes being from .054-inch diameter for half-inch rope up to .080-inch diameter for rope one inch in diameter and .105-inch for rope two inches in diameter.

The following information regarding the rope should be sent to the Department of Mines: name of manufacturer; diameter of rope; estimated breaking load as supplied by the manufacturer; name of shaft and compartment in which rope is used; date rope was put in use; and breaking load at previous test. Address, Mines Inspection Branch, No. 5 Queen's Park, Toronto, Ontario.

The laboratory at No. 5 Queen's Park is equipped with a 300,000-pound-capacity Tinius Olsen latest improved testing machine of four-screw type with special length screws and columns so arranged that the maximum clearance between the weighing table and lower surface of the lower or moving crosshead is six feet four inches, and with two positions in the columns for supporting the upper crosshead. The machine is equipped with automatic beam and speed regulating cones and with direct-connected motor drive. Instead of the ordinary rectangular holders and wedge-grip tools for tensile tests, the crossheads have conical holes. All cables are socketed in zinc for breaking tests.

Until further notice the rates charged will be according to the following schedule. Cables up to and including ⅞-inch diameter, $10.00; 1-inch and 1⅛-inch, $12.00; 1¼-inch, $15.00; over 1¼-inch, $20.00.

MINES OF ONTARIO

By

Chief Inspector of Mines, T. F. Sutherland, Toronto; Inspectors, J. G. McMillan, Cobalt; James Bartlett, Sudbury; A. R. Webster, Toronto; G. E. Cole, Ottawa.

The system of mine inspection in use in Ontario provides for the visitation of all working mines and metallurgical works, in order to see that the provisions of the Mining Act for the protection of mines and workmen are duly observed. These visits are made as often as the time of the inspectors will admit, or as occasion seems to require. In their examinations the inspectors also obtain particulars regarding mining and development work, and their notes are summarized in the following pages. Shareholders and the public generally are thus enabled to follow from year to year the rise and progress of any particular property in which they may be interested. First is given a classified list of the mines and metallurgical works inspected during 1921, the period covered by the Report.

MINES AND PROSPECTS INSPECTED, 1921

Name	Owner.	Manager.	Address.
CALCITE AND DOLOMITE.			
Baptiste	Ontario Dolomite Manufacturing Co., Ltd	Alex. Watson	76 Coleridge Ave., Toronto.
Caldwell	T. B. Caldwell		Perth.
COPPER.			
Algomont	Algomont Mines, Ltd	Geo. Johnson	Rydal Bank.
Jewel	Jewel Gold and Copper Mining Co., Ltd	W. J. Hands	Webbwood.
CORUNDUM.			
Craigmont	Corundum, Ltd.	E. B. Clark	Craigmont.
FELDSPAR.			
Emery	Eureka Flint and Spar Co.	R. Wagar	Verona.
Richardson	Feldspars Limited	Ralph Scott	Hartington, R.R. 1.
Babcock	Gardner Feldspar Co.	J. H. Mendels	Perth.
Hoppins	International Feldspar Co., Ltd	John A. McLean	316 Moffat Block, Detroit, Mich.
Long Lake	Orser and Wilson	Sherman Orser	Perth.
Keays	Rinaldo McConnell	Rinaldo McConnell	Perth.
Kirkham	“ “	“ “	“
Watson	Mount Eagle Feldspar Co., Ltd	M. B. R. Gordon	Hybla.
Burns	Orser-Kraft Feldspar, Ltd.	Sidney H. Orser	Perth.
Keays	“ “	“ “	“
Morrow	“ “	“ “	“
Woodcock	Pennsylvania Pulverizing Co.	R. H. Thompson	Hybla.
Robinson	Harry J. Cain		Tichborne.
Noonan	Rock Products Co.	A. G. Minehart	Toledo, Ohio.
Keays	“ “	“ “	“ “
Clobridge	“ “	“ “	“ “

MINES AND PROSPECTS INSPECTED, 1921—*Continued.*

Name	Owner	Manager	Address
Teeples	Storrington Feldspar Co., Ltd.	C. G. Walton	Elgin.
Vanluven	A. Vanluven		Holleford.
McDonald	Verona Mining Co	W. B. Couch	Hybla.
FLUORSPAR.			
Wallbridge	Wallbridge Bros.		Madoc.
GOLD.			
Argonaut	The Argonaut Gold, Ltd.	J. W. Morrison	Dane.
Beaumont	The Beaumont Gold Mines, Ltd.	S. H. Allen	South Porcupine.
Bidgood	The Bidgood Gold Mines, Ltd.	D. H. Angus	Kirkland Lake.
Big Dyke	The Big Dyke Gold Mines, Ltd.		Timmins.
Blanche Bay	The Blanche Bay Syndicate	Richard Haggerty.	Kenogami.
Cartwright	The Blue Quartz Gold Mines, Ltd.	J. J. Hollinger	Matheson.
Bousquet	Bousquet Gold Mines, Ltd	Robt. B. Tough	Willisville.
Burke	Under option to Hollinger.		
	Consolidated Gold Mines, Ltd.,		West Tree.
Goldale	Goldale Mines, Ltd.	H. A. Kee	Schumacher.
Goldfields	Canadian Associated Gold Fields, Ltd.	Geo. Gray	Dane.
Golden Fleece	The Cobalt Frontenac Mining Co.	D. H Fletcher	Flinton.
Bonanza	Contact Bay Mines, Ltd.	E. R. Rognon	Dryden.
Costello	Crown Reserve Mining Co., Ltd.	H. J. Stewart.	Dane.
Detroit	Detroit Goudreau Gold Development Co., Ltd.	C. G. Daimpré	Goudreau.
Dome	Domes Mines Co., Ltd.	H. P. De Pencier	South Porcupine.
Summit	The Golden Summit Mining Co., Ltd.	J. T. Kerr	Windsor.
Murphy	Goudreau Gold Mines, Ltd.	W. H. Reamsbottom	Goudreau.
Superior	Goudreau-Superior Mining Co., Ltd.	C. G. Daimpre	Goudreau.
Grace (On Eagle Lake)	Grace Mining Co., Ltd.	W. J. Richards	Kenora.
Hayden	Hayden Gold Mines, Ltd.	W. H. Hayden	Timmins.
Hollinger	The Hollinger Consolidated Gold Mines, Ltd.	A. F. Brigham	Timmins.
Hologden	Hologden Mines, Ltd.	Hart Martin	North Bay.
Howry Creek	The Howry Creek Mining Corporation, Ltd.	A. K. Anderson	Ottawa.
Jackson	The Jackson Development Co., Ltd.	W. S. Jackson	Schreiber.
King	The King-Kirkland Gold Mines, Ltd.	C. F. Jordan	Haileybury.
Kirk	Kirk Gold Mines, Ltd.	E. H. Birkett	Havilah.
Combined	Kirkland Combined Mines, Ltd.	A. W. Grierson	Kirkland Lake.
Kirkland Lake	The Kirkland Lake Gold Mining Co., Ltd.	W. M. Sixt	Kirkland Lake.
Lake Shore	The Lake Shore Mines, Ltd.	R. C. Coffey	Kirkland Lake.
Lightning River	Lightning River Gold Mines, Ltd.	J. W. Morrison	Dane.
Majestic	Majestic Gold Mines, Ltd.	M. A. Attalah	West Riv

MINES AND PROSPECTS INSPECTED, 1921—*Continued.*

Name	Owner	Manager	Address
McIntyre	McIntyre Porcupine Mines, Limited	R. J. Ennis	Schumacher.
Longworth	McKellar-Longworth	W. L. Longworth	Port Arthur.
Mikado	Mikado Consolidated Mines, Ltd	H. A. C. Machin	Kenora.
Miller-Adair	Miller-Adair Mines, Ltd	Chas. Miller	Toronto.
Miller Independence	Miller Independence Mines, Ltd	W. E. Simpson	Boston Creek.
Montreal-Kirkland	Montreal-Kirkland Mines Ltd	B. G. Killoran	Haileybury.
Northcrown	Northcrown Porcupine Mines, Ltd	H. J. Stewart	Timmins.
Ontario-Kirkland	Ontario-Kirkland Gold Mines, Ltd	Ralph Hurd	Kirkland Lake.
Ore Chimney	Ore Chimney Mining Co., Ltd	A. E. Fletcher	Northbrook.
Davidson	Porcupine Davidson Gold Mines, Ltd	N. J. Evered	South Porcupine.
Peninsular	Porcupine Peninsular Gold Mines, Ltd	A. R. Globe	Connaught.
Keora	Porcupine Keora Gold Mines, Ltd	J. C. Waite	South Porcupine.
Queen Lebel	Queen Lebel Gold Mines, Ltd	E. B. Wood	Haileybury.
Skead	Skead Gold Mines, Ltd	M. L. Bouzan	Haileybury.
St. Anthony	C. L. Campbell et al	C. L. Campbell	Montreal.
Teck Hughes	Teck Hughes Gold Mines Ltd	D. L. H. Forbes	Kirkland Lake.
Thesaurus	Thesaurus Gold Mines, Ltd	J. C. Nelson	Matachewan.
Tough Oakes	Tough Oakes Gold Mines	W. R. Thomas	Kirkland Lake.
Triplex	Triplex Gold Mines, Ltd	D. B. Harrison	South Porcupine.
Union	Union Mining Corp., Ltd	C. T. Denker	Timmins.
Wasapika	Wasapika Consolidated Mines, Ltd	G. R. Rogers	Coyne, Ont.
White Rock	White Rock Mining Co., Ltd	J. McVittie	Sudbury.
Wright-Hargraves	The Wright-Hargraves Mines, Ltd	A. Wende	Kirkland Lake.
GRAPHITE			
Black Donald	Black Donald Graphite Co	R. F. Bunting	Calabogie.
GYPSUM.			
Caledonia	Ontario Gypsum Co., Ltd	A. J. Parkhurst	Caledonia.
Lythmore	" "	" "	"
IRON.			
Magpie	Algoma Steel Corp	G. R. McLaren	Magpie Mine.
Mason-Wilcox	Mason-Wilcox Syndicate		Sault Ste. Marie.
Moose Mountain	Moose Mountain, Ltd	A. J. Anderson	Sellwood.
Palatine	Palatine Mining and Development Co	Arthur Mitchell	Duluth.
Atikokan	Under option to Clement A. Quinn		Duluth.
Goulais River	Under option to Chas. R. Sligh		Grand Rapids, Mich.

MINES AND PROSPECTS INSPECTED, 1921—*Continued.*

Name	Owner	Manager	Address
IRON PYRITES.			
Northpines	Nichols Chemical Co.	J. P. Flynn	Northpines.
Sulphide	“ “	W. H. De Blois	Sulphide.
Rand	Rand Consolidated Mines, Ltd	A. H. Jackson	Buffalo.
LEAD.			
Hollandia	Arnprior Syndicate	C. Thompson	Arnprior.
Kingdon	Kingdon Mining Smelting and Manufacturing Co.	R. R. Rose	Galetta.
Frontenac	Northern Lead Co.	J. B Bell	Montreal.
MICA.			
Acton	Acton Mines, Ltd	C. J. Acton	Gananoque.
Howes	H. J. Cain	H. J. Cain	Tichborne.
Folger	“ “	“ “	“
Lacey	Loughborough Mining Co.	G. W. McNaughton	Sydenham.
MOLYBDENITE.			
Wilberforce	American Molybdenites, Ltd	W. E. T. Barton	Wilberforce.
NICKEL.			
Murray	British America Nickel Corporation	E. Hibbert	Nickelton.
Creighton	International Nickel Co.	J. L. Agnew	Copper Cliff.
Bruce	Mond Nickel Company	A. D. Carmichael	Bruce Mines.
Garson	“ “	A. L. Sharp	Garson.
Levack	“ “	F. J. Eager	Levack.
Victoria	“ “	W. J. Mumford	Mond.
Worthington	“ “	A. D. Carmichael	Worthington.
SILVER.			
Chambers-Ferland	Aladdin Cobalt Co., Ltd.	J. Matheson	Cobalt.
Alpine	Alpine Silver Mines, Ltd.	E. J. Thompson	Gowganda.
Bailey	Bailey Silver Mines, Ltd.	R. E. Dye	Cobalt.
Cobalt A-53	Cobalt A-53 Silver Mining Co., Ltd	J. J. Byrne	Cobalt.
Collins	F. Howard Collins	F. H. Collins	Gowganda.
Coniagas	The Coniagas Mines, Ltd.	F. D. Reid	Cobalt.
Dickson Creek	The Dickson Creek (Cobalt) Silver Mines, Ltd.	H. Hollands-Hurst	Haileybury.
Federal	The Federal Mining Co., Ltd	Wiley	Port Arthur.
Frontier	Dominion Mines & Quarries	H. F. Strong	Haileybury.
Keeley	The Keeley Silver Mines	J. Mackintosh Bell	Silver Centre.
Kerr Lake	Kerr Lake Mines, Ltd	H. A. Kee	Cobalt.
La Rose	La Rose Mines, Ltd	G. C. Bateman	Cobalt.
Princess	“ “	“ “	“
University	“ “	“ “	“
Violet	“ “	“ “	“
Mining Corporation	The Mining Corporation of Canada, Ltd.	M. F. Fairlie	Cobalt.
Nipissing	Nipissing Mines Co., Ltd.	Hugh Park	Cobalt.
Miller Lake O'Brien	M. J. O'Brien, Ltd	H. G. Kennedy	Gowganda.
O'Brien	“ “	J. G. Dickenson	Cobalt.
Northcliffe	Northcliffe Mines, Ltd	N. E. Dye	Gowganda.
Solid Silver	Ontario Solid Silver Mines.	Roy Sullivan	Elk Lake.
Oxford Cobalt	Oxford Cobalt Silver Mines	J. W. Russell	Cobalt.
Reliance	Hermo Leasing Co.	W. H. Emens	Cobalt.

MINES AND PROSPECTS INSPECTED, 1921—*Continued.*

Name	Owner	Manager	Address
Sanderson	Under option to Stewart Troop		Montreal.
Shoefelt	Jacob Shoefelt	W. H. Todd	McLennan.
Silver Cliff	Under lease to Bailey Silver Mines, Ltd	G. C. Bateman	Cobalt.
Silver Islet	The Islet Exploration Co., Ltd	D. C. Peacock	Port Arthur.
Silver Queen	Under lease	W. J. Post	Cobalt.
Castle	Trethewey Silver Cobalt Mining Co	M. D. Kennedy	Gowganda.
Victory	Victory Silver Mines, Ltd	J. A. McVichie	Cobalt.
TALC.			
Connolly	Asbestos Pulp Co	H. B. Hungerford	Madoc.
Price	" "	" "	"
Henderson	Geo. H. Gillespie & Co	Geo. H. Gillespie	Madoc.

METALLURGICAL WORKS INSPECTED, 1921

Works.	Owner.	Manager.	Address.
Blast Furnaces	Algoma Steel Corporation	James D. Jones	S. S. Marie.
" "	Canadian Furnace Co	G. J. Higgins	Port Colborne.
" "	Steel Company of Canada	H. G. Hilton	Hamilton.
Silver-Cobalt Refinery	Coniagas Reduction Co	D. A. Mutch	Thorold.
" " "	Doloro Smelting and Refining Company	S. B. Wright	Deloro.
Nickel Refinery	International Nickel Co	John More	Port Colborne.
Cobalt Refinery	Ontario Smelters and Refiners	J. F. Hickling	Welland.

1.—NORTHWESTERN ONTARIO

Gold

Contact Bay Mines, Limited.—This company shut down its Bonanza mine on December 31, 1921, and resumed mining in the spring.

When last inspected, March 9, 1922, the shaft, an 80-degree incline, measured 170 feet. On the 80-foot level there was 214 feet of drifting to the east, 170 feet to the west, and a 90-foot inclined raise to the surface. On the 160-foot level drifting was in progress, and the faces were then 125 feet east and 135 feet west of the shaft.

Harry S. Badger, who has been manager for the company for some years, left the company's employ in March, 1921; E. R. Rognon is now acting as managing director. E. S. Henley, superintendent, resigned in September, and was succeeded by Charles W. Riley.

Empress.—The Empress mine near Jackfish was pumped out and sampled in 1921 by an American syndicate. The mine is owned by the Czarina Gold Mines Company of Ontario, Limited, which was incorporated August 28, 1901, with a capital of $40,000, and which succeeded the Empress Gold Mining Company of Ontario, Limited. The last officers of the company were: president, D. McKellar, Fort William, (now deceased): vice-president, Walter Ross, Lethbridge, Alta.; secretary-treasurer, W. L. Morton, Fort William.

Grace, (Eagle Lake).—The Grace gold mine on the west side of Eagle lake in the Manitou lake area was worked during nine months of the year. Captain Walpole Roland was at first in charge, but was succeeded by William J. Richards of Kenora in June. The mine is owned by The Grace Mining Company, Limited, of 8 Brisbane Building, Buffalo, N.Y. The directors are: George J. Blake, president; Charles Oelheim, secretary and treasurer: and Charles P. Blake: all of Buffalo, N.Y. The post office address for the mine is Vermilion Bay, Ont.

When work was discontinued for the winter on December 15, 1921, the two-compartment shaft was 187 feet deep and had an average dip of 86 degrees. On the first level, which is at about 100 feet, there is a crosscut running northwest to the vein a distance of 20 feet from the shaft, and from the face of this crosscut drifts extend about 15 feet to the northeast and 25 feet to the southwest: the work on the first level was done between 15 and 20 years ago. On the second, or 180-foot level there is a crosscut 45 feet to the northwest and a second 45 feet to the southeast, but no drifting has been done.

Jackson.—The Jackson Development Company, Limited, owns eight mining claims on the Canadian Pacific Railway about two miles east of Schreiber. The claims are: T.B. 3326, T.B. 3411, T.B. 3413, T.B. 3588, T.B. 3589, T.B. 3815, T.B. 3783, and T.B. 3795. For the past seven years the prospecting of these claims has been carried on under the direction of Wm. S. Jackson.

When the property was last inspected in March, 1922, ten men were employed and two adits were being driven into the side of a hill on claim T.B. 3326 a short distance north of the railway. No. 1 adit measured 60 feet and No. 2 adit 40 feet. No underground work has been done on the other claims. The buildings on the property consist of a dining room, a sleeping camp, two small cabins, a stable, and an ore bin with sorting room attached.

The company was incorporated on October 1, 1921, with a capitalization of $40,000. One-half of the stock has been sold at par, and the remainder is in the treasury. The officers are: president, W. H. Russell, Port Arthur; vice-president, Chas. N. Gray, Detroit: secretary, W. F. Langworthy, Port Arthur; treasurer, Wm. S. Jackson, 297 Frederick Street, Fort William; directors,—the above-mentioned and,—Alex. D. Hunt, Port Arthur, and Harold D. Emmons, Detroit, Mich. The head office is at Port Arthur, Ont., and the address for the mine is Box 107, Schreiber, Ont.

McKellar-Longworth.—The veins on the McKellar-Longworth property, mining location B.J. 122, are described elsewhere in this report by P. E. Hopkins of the geological staff.

The property was inspected March 16, 1922, when ten men were at work under foreman J. B. Amm. The adit on the vein then measured 85 feet, the north crosscut 59 feet, and the south crosscut 30 feet. No. 2 shaft was 20 feet deep and No. 4 shaft 40 feet. The owners, Peter McKellar of Fort William and W. L. Longworth of Port Arthur, had just given an option on the property to George Glendinning of Toronto.

Mikado Consolidated.—On November 16, 1921, Mikado Consolidated Mines, Limited, was incorporated under the Ontario Company's Act with a capitalization of $5,000,000 divided into shares of $1.00 par value. Two million shares have been paid for the mining property, leaving three million shares in the treasury.

The company's holdings are situated on Shoal lake and are as follows:

(1) The Mikado mine, consisting of Locations D. 147, D. 148, D. 149, D. 200, D. 201, and D. 201A, some 278 acres in all, with the machinery, 20-stamp mill, and buildings thereupon.

(2) An option to purchase the Tycoon mine, which consists of Locations J.E.S. 54, D. 219, D. 220 and D. 221, some 40 acres in all.

(3) An option to purchase the Bullion mine, which consists of Locations S. 109, S. 126, S. 150, S. 151, D. 233, D. 239, and D. 389, some 447 acres in all.

The Tycoon and Bullion properties adjourn the Mikado mine.

The directors of the company are: president, Lieut.-Col. H. A. C. Machin, Kenora; vice-president, George J. Guy, Hamilton, Ont.; secretary and treasurer, Major George H. Marsh, Toronto; J. T. White, Toronto; A. W. Hunter, Toronto. The head office of the company is in Kenora, but an office is also maintained at Suite 501, Kent Building, Toronto.

St. Anthony.—In January and February, 1921, C. L. Campbell and associates conducted some experiments at the St. Anthony mine on the ore and tailing. This mine is on Couture lake in the Sturgeon lake area.

Wachman.—The Wachman Mining and Milling Company, Limited, made an assignment on January 14, 1922. Since December, 1920, nothing has been done on this company's claims, which are near Dryden, Ont.

Iron

Atikokan.—Early in 1921 Clement A. Quinn of Duluth took an option on the Atikokan iron mine near Atikokan, Ont., but, so far as has been learned, he has not done any mining on the property.

Palatine.—In the spring of 1921 it was announced that the Palatine Mining and Development Company of Chicago, the directors of which are Polish-Americans, had bought the Paulson mine and some adjacent property in Cook County, Minnesota, and the Atikokan blast furnace at Port Arthur, Ont. The company did considerable repair work at the furnaces and began to extend the Port Arthur and Duluth railway from the end of the track at North Lake, Ont., to the Paulson mine, a distance of some 21 miles. The blast furnaces were not put in operation in 1921.

According to a correspondent of the Engineering and Mining Journal the officers of this company are as follows: Joseph Mierzynski, president, Chicago; Frank Wydra, secretary, Chicago; Stanley Grzybowski, treasurer, Chicago; Arthur Mitchell, consulting engineer, Duluth; Thomas Krakowiak, chemical engineer, Palatine City, Minn.; Roman Turczynowicz, construction engineer, Chicago; Maximillian J. St. George, general counsel, Chicago; James Ostrowski, director, Chicago; and Edward A. Zolkowski, director, Chicago.

Iron Pyrites

Northpines.—The Nichols Chemical Company, Limited, worked its Northpines pyrite mine to a small extent in 1921.

From No. 1 shaft crosscuts were driven on the third and fourth levels to the main drifts on the vein. In February the main or No. 2 shaft was completed to the sixth level, and the sixth level station was then cut. Crosscuts to the hanging walls were driven on the fifth and sixth levels, and from a point in the shaft 20 feet above the sixth level an ore-pocket raise was driven to the fifth level and the ore pocket partly excavated. Since September practically no underground work has been done.

From April to September 14,090 tons of pyrite were hoisted and crushed, and 13,635 tons were stockpiled at the railway: the difference between these figures represents the amount of waste removed by sorting.

A 37½-horsepower Type Y Fairbanks-Morse oil engine is being used to furnish power during the shutdown.

J. P. Flynn, Jr., Northpines, is superintendent.

Silver

Federal.—The Federal Mining Company, Limited, owning a mining claim in lot 26, concession B, Paipoonge township, stopped work at the end of 1921, and the underground workings are as described in the Thirtieth Annual Report of this Department.

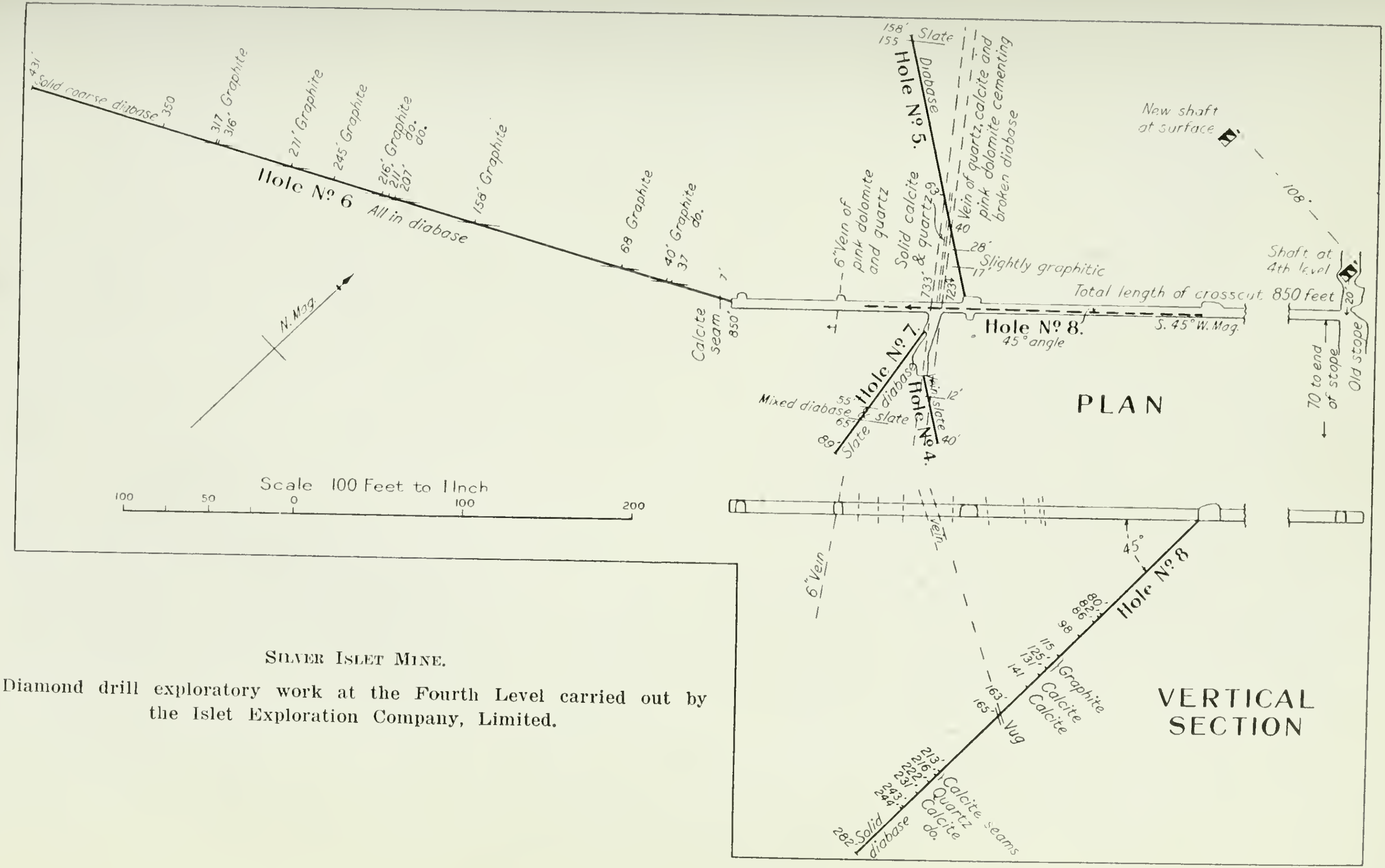
Silver Islet.—Islet Exploration Company, Limited, was incorporated on Jan. 3, 1921 with an authorized capital of $250,000; about $120,000 of this stock has been issued. The officers of the company are: president, J. L. Washburn; vice-president, D. C. Peacock; secretary, A. M. Washburn; treasurer, R. M. Sellwood. The office of the company is at 509 Alworth Building, Duluth, Minn.

This company was formed to search for ore in the Silver Islet mine consequent on the preliminary investigation made in 1920 by R. C. Jamison and D. C. Peacock and described in the Thirtieth Annual Report of this Department.

Mr. Peacock, who, in addition to being the vice-president, is also the mining engineer of the company, has been kind enough to supply the following notes regarding the recent work at this famous mine:

> The work done at Silver Islet in 1921 was confined to the fourth level which is at a vertical depth of 225 feet below the collar of the shaft. A crosscut was driven 850 feet to the southwest in te Macfarlane like and disclosed two veins, one about ten feet in width, and the other about six inches. After a distance of 40 feet had been driven southerly on the 10-foot vein a heavy flow of water was encountered, preventing further work in that direction. Drifting was started northward on the 6-inch vein, but this face also had to be stopped on account of water. It was then decided to resort to diamond drilling to prospect the veins already found and to explore the ground to the southwest for additional veins. Five holes, totalling 1,000 feet, were driven from this level. Practically no silver was found in the veins by crosscut, drifts, or diamond drill holes. There was very little graphite in the diabase and none whatever in the vein-filling. The accompanying plan and section depicts the position of the work done. The graphite noted on this drawing was in traces only; in the old workings the graphite occurred in considerable quantities. We ascribe the lack of silver in the veins tested to the comparative absence of graphite in the country rock.

A plan of the new workings is reproduced on the following page.



SILVER ISLET MINE.

Diamond drill exploratory work at the Fourth Level carried out by the Islet Exploration Company, Limited.

II.—SUDBURY, NORTH SHORE AND MICHIPICOTEN

Gold

Detroit-Goudreau.—Detroit-Goudreau Gold Development Company, Limited, was incorporated on January 11, 1922, with an authorized capital of $2,500,000 divided into shares of $1.00 par value. The company has bought fourteen mining claims in the Goudreau area, giving therefor 1,400,000 shares of stock. The company's prospectus describes these claims as being situated about one and a quarter miles due east of the Murphy discovery.

The head office of the company is in the Royal Bank Building, Windsor, Ont., and the directors are as follows: president, Fred W. Sparling, Detroit, Mich.; vice-president, Robert R. Richards, Detroit; secretary-treasurer, Netter J. Hill, Detroit; Wm. J. Daeschner, Detroit; G. Cosby Geissler, Detroit; Homer M. Howe, Windsor, Ont.; G. Robert Livingstone, Goudreau, Ont.; Adna K. Masters, Detroit; Carl W. Mulcahy, Detroit; H. Coleman Smith, Detroit; Eugene A. Wigren, Detroit. Most of the directors are in the auditing department of the Michigan Central Railroad Company. Charles G. Daimpré is to be in charge of the work on the property.

Goudreau Gold Mines, Limited.—This company was incorporated to work the Murphy and some adjoining claims in the Goudreau area. The capitalization is $2,500,000, divided into shares of $1.00 par value. The directors are: A. R. Porter, Toronto, president; M. P. Van der Voort, Toronto, secretary-treasurer; Clement A. Foster, Toronto, managing director; W. I. Hearst, Toronto; A. V. J. Selkirk, Franz, Ont. The head office is at 312 Temple Building Toronto.

The company owns a group of twelve mining claims, 534 acres in all, situated in the centre of township 28, range 26, district of Algoma. A million and a half shares of stock were given for the original four Murphy claims, leaving one million shares in the treasury. Eight additional claims were purchased later with a relatively small amount of stock and a small cash payment. The mine is approximately one mile south and three miles west of Goudreau station on the Algoma Central and Hudson Bay railway.

The geological conditions in the vicinity of the Murphy vein have been described by A. G. Burrows of this Department.[1]

A five-mile road has been cut from Goudreau station to the property and camps have been built. The main vein has been trenched and two shafts started, both of which were 25 feet deep at the end of the year. No. 1 shaft is in the southeast corner of mining claim A.C. 408 at the point where the vein was first discovered; the vein here has a dip of 65 degrees to the south. No. 2 shaft is also on the vein 500 feet to the west of No. 1, and is vertical.

Arrangements have been made with the Algoma Steel Corporation for a supply of power from the Steep Hill Falls plant on the Magpie river. This will necessitate the construction of about five miles of transmission line.

W. H. Reamsbottom, Goudreau, Ont., is superintendent, and Albert Terrill, mine foreman.

---

[1] Ont. Dept. Mines, Vol. XXX, pt. 4, pp. 39-44.

Goudreau-Superior.—Goudreau-Superior Mining Company, Limited, was incorporated in Ontario on January 31, 1922, with an authorized capital of $1,500,000 in shares of $1.00 par value. For a consideration of 800,000 shares of the stock and the sum of $10,750, the company bought a block of six mining claims. The company's prospectus describes this block as lying directly west of the properties of the Detroit-Goudreau Gold Development Company, Limited, and the Rand Consolidated Mines, Limited, and adjoining the property of Goudreau Gold Mines. Limited on the east and south.

The directors all live in Detroit, Mich., and are as follows: Netter J. Hill, president; Edward Leszczynski, vice-president; Fred W. Sparling, secretary-treasurer; Berton A. Aikens; John J. Danhof, Jr.; Clarence H. Ladd; Adna K. Masters; Edward M. Pennell; Robert R. Richards; Joseph T. Sullivan; Hugo Zander. Charles G. Daimpré is to be in charge of the prospecting of the claims. The head office is in the Allen Theatre Building, Windsor, Ont.

Grace.—The Grace gold mine in the Michipicoten area near Wawa lake was pumped out and sampled in June and July, 1921. Horace G. Young was the engineer in charge of the examination.

Kirk Gold.—Kirk Gold Mines, Limited, now has the following directorate: George A. Bull, Brampton, Ont., president; R. B. Burkell, Toronto; C. L. Messecar. Brantford, Ont.; Robert Kennedy, Toronto; E. H. Birkett, Havilah, Ont.; director and manager.

At the Bass Lake property the adit was continued to a distance of 625 feet from the portal. As the vein did not seem to warrant further expenditure, work was stopped at this prospect.

The company has bought the Ophir or Havilah mine, which is in lot 12, concession III, Galbraith township, and has been described in some of the early reports of this Department.[1] No work was done here in 1921, other than pumping out the mine for examination and repairing some of the buildings.

Iron

Goulais River.—In December, 1921, diamond drilling was begun in behalf of Charles R. Sligh, Grand Rapids, Mich., on a property forming part of the Goulais river iron range. The property is twelve miles east of mileage 60 of the Algoma Central and Hudson Bay railway, is in the southwestern part of township 22, range XIII, district of Algoma, and consists of eight mining claims. The drilling, 2,750 feet, was confined to two of these claims, S.S.M. 1,289 and S.S.M. 1,293.

Algoma Steel Corporation.—The Algoma Steel Corporation, a subsidiary of the Lake Superior Corporation, owns the steel plant at Sault Ste. Marie, Ont., and the Magpie iron mine in the Michipicoten district.

The officers of the Algoma Steel Corporation are: president, W. C. Franz; vice-president, James Hawson; general manager, James D. Jones; assistant general superintendent, Joseph W. Wilson; chief engineer, F. Smallwood; works engineer, C. H. Speer; superintendent of blast furnaces, James H. Bell; superintendents of open hearths, A. H. Hugill and J. McDonald; superintendent of bloom and rail mill, O. Davies; superintendent of merchant mill, James Lycett; superintendent of coke plant, William Seymour; mechanical superintendent, Carl Stenbol. The secretary is Alex. Taylor, Traders' Bank Building, Toronto.

---

[1] Ont. Dept. of Mines, Vol. III, pp. 37-45; Vol. IV, p. 206, etc.

Magpie.—On March 8, 1921, mining and roasting was stopped at the Magpie mine, and about a month later the mine workings were allowed to fill with water.

When the mine shut down, drifting had been carried on the fifth (the lowest) level 335 feet west of the station and 350 feet east. The ore on this level is of good grade, and fortunately the "mica dyke," which entered the ore body above the third level and has been a source of trouble in some of the stopes, seems to disappear a short distance above the fifth level. On the fifth level to east of the shaft most of the ore body has been developed and part of it has been stoped; to the west of the shaft No. 14 stope has been partly developed, but the diabase dyke has not yet been reached. Above the fourth level some ore remains in stopes 10 and 11 west of the shaft.

The production of roasted ore for the year was 42,198 (short) tons, and shipments totalled 58,401 tons.

George R. McLaren, Magpie Mine, Ont., was superintendent and Robert P. Welden, assistant superintendent. George S. Cowie, Sault Ste. Marie, Ont., is secretary of the Mines Department of the Algoma Steel Corporation, which owns the Magpie.

Mason-Wilcox.—For the past two years a syndicate of residents of Sault Ste. Marie, Ont., has been prospecting some iron claims a mile southeast of Northland station on the Algoma Central and Hudson Bay railway. In the autumn of 1921, a diamond-drill hole was put down near the southwest corner of the northwest quarter, south half, lot 2, concession II, township of Deroche. The property was not visited by the writer, but a reliable informant described the prospect as follows: At the southwest corner of the lot-fraction mentioned above a diabase dyke, 200 to 250 feet wide, cuts the granite in a northwesterly direction, and, on the south contact of the diabase with the granite, several pockets of hematite are exposed.

Moose Mountain.—The mine, concentrator, and agglomerating plant of Moose Mountain, Limited, at Sellwood, Ont., have been closed down since November, 1920, and only some repairing and experimental work were undertaken in 1921, 79 tons of briquettes were shipped during the year.

A. J. Anderson resigned as manager in November, 1921, since which time C. M. Tolman, the company's electrician, has been temporarily in charge.

Copper

Algomont.—Algomont Mines, Limited, was incorporated in 1920, with an authorized capital of $4,000,000 divided into shares of $1.00 par value each. Two million shares of the stock were paid to a syndicate for the mining lands now held by the company. These lands consist of 805 acres and are known as the Asam and McPhee properties. The Asam property consists of 485 acres subdivided as follows: the south half of lot 1, concession VI, and the north half of lot 1, concession V, Plummer township, and the southwest quarter of section 6, Rose township. The McPhee property covers 320 acres and comprises the southeast quarter of section 6, and the southwest quarter of section 5, Rose township.

The company began work in April, 1921, and, after building camps and completing one and a quarter miles of wagon road, bought and erected the following machinery: two 50 h.p. locomotive-type boilers, a Rand compressor with 16-inch by 24-inch cylinders, and a 6-inch by 8-inch Jenckes hoisting engine.

The vein on which work is being done is the "Asam" vein in the southwest quarter of section 6, Rose township; it strikes east and west, is in diabase, and consists of quartz, ankerite and copper pyrites. East of the shaft the vein is exposed in two places: at 140 feet from the shaft it is from two feet six inches to three feet wide; at 195 feet it is two feet wide and at this latter point ankerite is the predominating mineral. From about 600 to 700 feet west of the shaft what is probably the same vein is exposed and several test pits have been sunk; the width of the vein in these pits varies from three feet six inches to six feet. On July 20, 1921, a shaft was started, and on January 31, 1922, it measured 200 feet; this shaft follows the vein which at this point dips to the north at about 75 degrees. In the shaft the vein has an average width of four feet.

There is also a shaft, said to measure 6 feet by 6 feet by 60 feet in depth, on No. 1 vein of the McPhee property in the southeast quarter of section 6, Rose township, but no work has been done at this point by the present owners.

The directors of the company are: Charles N. Haldenby, president, Toronto; John Black, vice-president, Toronto; Dr. A. Moir, Peterborough, Ont.; Richard B. Rogers, Peterborough, Ont.; E. R. Wilson, Peterborough, Ont. The secretary-treasurer is Ziba Gallagher of Toronto, and the company office is in the Bradburn building, Peterborough, Ont.

John A. MacDonald was superintendent until September 1921, when he resigned and was succeeded by George Johnson. About 26 men are employed. The postal address of the mine is Rydal Bank, Ont.

Jewel.—The Jewel Gold and Copper Mining Company, Limited, was incorporated on March 11, 1919, with a capital of $300,000. The capital stock was increased on April 4, 1921, to $1,000,000. The company was formed to work some veins reported to contain gold and copper and situated in lots 11 and 12, concession I, Shakespeare township, about two miles northwest of Webbwood. The company did a little prospecting on the property in the spring of 1921, stopping work on June 15.

The head office of the company is at 67 Richmond Street West, Toronto, and the officers are: president, Joseph H. Vanderlip; secretary-treasurer, James M. Armstrong; general manager, Wm. J. Hands; directors, Wm. J. Hands, Wm. H. Moody, Stephen G. Thompson, Francis E. Cope, all of Toronto.

Nickel and Copper

Owing to the large stocks of refined nickel on hand, only 262,593 tons of nickel-copper ore were shipped from the mines of the Sudbury district to the smelters in 1921; this is the lowest output recorded since 1903. The lack of demand for nickel resulted in the cessation of all work by the British America Nickel Corporation in February and by the International Nickel Company in August. The Mond Nickel Company succeeded in keeping all its mines operating on a small scale and one blast furnace running at capacity.

Wages were twice reduced and at the end of the year the prevailing rates in the district were approximately, miners $4.20 per day, trammers $3.70 per day, and for unskilled surface labour at the mines and smelters from 30 to 34 cents an hour.

British America Nickel Corporation, Limited

Owing to the lack of demand for nickel the British America Nickel Corporation, Limited, was compelled to close down its mine and smelter at Nickelton on February 26, 1921, and its refinery at Deschesnes, Que., a month or two later.

During the year the financial condition of the corporation became such as to render a reorganization necessary. This has been effected and the securities issued now consist of $20,000,000 common stock, $6,000,000 first income bonds, $6,000,000 "A" income bonds, and $12,500,000 "B" income bonds.

The directors are now as follows: Hon. E. N. Rhodes, Ottawa, president and managing director; Captain D. Vogt, Kristianssand, Norway, vice-president and managing director of the corporation's European office; Victor Hybinette, Wilmington, Del., vice-president; A. Gronningsaeter, Ottawa, Ont., technical director; S. M. Brown, Ottawa, Ont., secretary-treasurer; The Rt. Hon. Sir Robert Borden, Ottawa; Sir U. J. R. Borresen, Kristiana, Norway; Sir Eric Hambro, London, Eng.; E. A. Cappelen Smith, New York, N.Y.; J. Fred Booth, Ottawa, Ont.; S. Giertsen, Kristianssand, Norway; Oscar Jebsen, Kristianssand, Norway; P. C. Stevenson, Ottawa, Ont.; E. R. Wood, Toronto, Ont.

Nickelton Smelter.—One of the two blast frunaces at the British America Nickel Corporation's smelter at Nickelton was kept in blast until the shut-down on February 26, 1921; since this date the plant has been idle.

At the end of the year the following members of the operating staff were still at the smelter: E. J. Carlyle, manager; Oliver E. Jager, superintendent; blast furnace superintendent, T. W. Cavers; converter superintendent, B. C. Tomlinson.

Murray Mine.—Up to February 26, 1921, 400 men were employed at the Murray mine; after this only 28 men were retained to sink a winze preparatory to shaft-raising. This winze was sunk from the 800-foot level, where a hoisting engine was placed, to 20 feet below the 1,300-foot level. A crosscut was started from the winze toward the shaft on the 1,300-foot level, but had not been completed when all work was stopped at the end of October.

Ernest Hibbert is manager of mines and H. L. Roscoe is superintendent.

International Nickel Company of Canada, Limited

The International Nickel Company of Canada, Limited, owns and operates mines and a smelter in the Sudbury district and a nickel-copper refinery at Port Colborne, Ont. The officers are: John L. Agnew, Copper Cliff, president; F. S. Jordan, New York, vice-president; Britton Osler, Toronto; secretary; directors, Robert C. Stanley, New York City; Alfred Jaretzki, New York City; James L. Ashley, New York City; John L. Agnew, Copper Cliff; John More, Port Colborne, Ont.; W. B. Lawson, New York City; F. S. Jordan, New York City; Britton Osler, Toronto.

In 1921 the company had an average of about 675 men employed in the Sudbury district until the Creighton mine and the smelter were closed toward the end of August; since the shut-down about 175 men have been employed on maintenance and repair.

The International Nickel Company owns all the stock of the International Nickel Company of Canada, Limited. The stock of the parent company consists of: common shares (par $25.00)—$50,000,000 authorized, $41,834,600 outstanding; 6 per cent. non-cumulative preferred shares (par $100)—12,000,000 authorized, $8,912,600 outstanding. The officers of the parent company are: Chairman, Charles Hayden, New York City; president, Robert C. Stanley, New York City; vice-president, secretary and treasurer, James L. Ashley, New York City; comptroller, James W. Beard, New York City; directors, Admiral Willard H. Brownson, Washington, D.C.; W. E. Corey, New York City; Alfred Jaretzki, New York City; Charles Hayden, New York City; William N. Cromwell, New York City; Thomas Morrison, Pittsburgh, Pa.; Seward Prosser, Englewood, N.J.; Robert C. Stanley, New York City; William T. Graham, Greenwich, Conn.; W. W. Mein, New York City; James L. Ashley, New York City; Britton Osler, Toronto; John L. Agnew, Copper Cliff, Ont. The general offices are at Bayonne, New Jersey, and the executive and financial offices at 67 Wall Street, New York.

The officers residing in Copper Cliff, in addition to those mentioned elsewhere in this report, are: president, John L. Agnew; general superintendent, John C. Nichols; superintendent of mines, E. T. Corkill; master mechanic of mines, David Butchart; electrical superintendent, J. B. McCarthy; transportation superintendent, G. A. Sprecher; safety engineer, William O. Tower; works auditor, F. C. Allgeier.

The following information is abstracted from the twentieth annual report of the parent company and covers the fiscal year ending March 31, 1922:

> The general depression existing in the metal industry since 1920 became more acute during the twelve months covered by this report and seriously affected your company's business. The demand for the company's product decreased to such an extent that the total sales were less than during any similar period since 1904. Our nickel sales fell off sixty per cent. from the previous year and monel metal sales, though relatively better, decreased thirty-three per cent. This condition called for drastic curtailment and economies.
>
> During August, 1921, all mining and smelting operations were suspended, and the refineries at Port Colborne and Bayonne were practically closed. The total force of employees was reduced to a number sufficient to maintain your plants in good condition and to form the nucleus of an organization which could, when required, promptly and efficiently resume operations. Wages and salaries of all those remaining in the organization were cut substantially.
>
> With a view to future economy of production it was decided to close permanently the Orford Works, Bayonne, and concentrate all nickel refining operations at the Port Colborne, Ontario, refinery, and all operations in connection with rolling monel metal at the company's new plant at Huntington, West Virginia.
>
> The Monel Metal Products Corporation at Bayonne, all of whose stock was owned by your company, has been dissolved and merged with The International Nickel Company. This Bayonne plant will continue to operate as a foundry and warehouse.
>
> During the year rapid progress was made in the construction of the company's new monel metal rolling-mill at Huntington, West Virginia. These works will be ready for operation during the summer of 1922. The total cost, including equipment on hand, is estimated at $3,400,000 of which $2,935,000 has been expended to May 1, 1922.

The consolidated general balance sheet and profit and loss account of the company and its subsidiaries show the company to be in a sound financial condition.

The operating profit for the year was $83,604.34. After providing $437,720.57 for depreciation and depletion and $428,630.70 for expense and maintenance of shut-down mines and plants, the loss for the year was $797,746.93. This loss, plus adjustment of inventories, etc., of $537,833.89, and the payment of the preferred dividend result in a total debit to the surplus account of $1,870,336.82. Inventories now amount to $9,340,589.86 as compared with $11,891,078.23 a year ago.

There was written off the property account for dismantlement $286,575.48, which amount was charged to depreciation of plant reserve account.

Four dividends of 1½ per cent each on the preferred stock of the company have been paid during the fiscal year. The net earnings for the year of the International Nickel Company of New Jersey, inclusive of dividends received from its subsidiaries, were in excess of the amount so distributed. No dividends were paid on the common stock.

The company's business during the first three months of 1922 indicates general improvement in the nickel industry. Monthly sales increased and inquiries for various products became more numerous. Foreign business is slowly becoming stabilized and further improvement is quite evident. Stocks of finished metals have been liquidated to such an extent that the Port Colborne refinery was started on May 1, 1922, and the mine and smelter at Copper Cliff will be started not later than Sept. 1, 1922.

During the year a department was organized to develop new uses for nickel and monel metal, and to extend their known uses. The activity of the development department, coupled with well-directed sales effort, should provide for the new rolling mill profitable tonnage in both rolled nickel and monel metal. It is the belief of the management that a demand for finished nickel in the form of sheets, rods and wire can be created which will offset tonnage previously sold for armament uses.

The number of stockholders increased during the fiscal year from 16,206 to 17,714.

Copper Cliff Smelter.—One, and for a short time two, of the furnaces at Copper Cliff were in operation until the plant was shut down at the end of August. The wedge and reverberatory furnaces have been idle since January 14, 1921.

The officers at the smelter are: superintendent, William Kent; assistant superintendent, Donald MacCaskill; metallurgist, James W. Rawlins; master mechanic, George R. Craig; blast furnace foreman, Peter McDonald; converter foreman, Frank Taylor; reverberatory foreman, Joseph K. Workman.

Creighton Mine.—The Creighton mine was worked on a small scale until August 26, 1921, when all mining was stopped and only a few men were retained on pumping and maintenance. The number of employees varied from 220 in January to 127 in August. Shipments of ore aggregated 51,382 tons for the year. The main shaft remains as at the close of last year, but is now connected with the bottom of No. 10 hanging-wall winze by means of a crosscut on the 30th level.

The staff at the mine includes: superintendent, George A. Morrison; assistant superintendent, W. J. Rolfe; mine foremen, K. C. Browne and Charles Collins; master mechanic, John Symons; electrician, Everett Gillespie.

Dill Quarry.—Dill quarry at Quartz, Ont., was worked during the months of June and July with a force of 45 men. Shipments of quartz to Copper Cliff smelter totalled 23,148 tons. Walter Blackwell was superintendent.

Mond Nickel Company, Limited

The Mond Nickel Company now has the following directorate: Robert L. Mond (chairman), C. V. Corless, LL.D., Viscount Erleigh, Sir E. J. Griffith, Sir Robert A. Hadfield, Dr. Carl Langer, Robert Mathias, Emile S. Mond, S. W. A. Noble, Sir Byron Edmund Walker. The secretary is D. Owen Evans, 39 Victoria Street, London, S.W., England.

The Canadian staff of the company, exclusive of those mentioned under the several properties, is as follows: Dr. C. V. Corless, manager; Oliver Hall, superintendent of mines; John F. Robertson, superintendent of reduction works; W. H. Soule, electrical superintendent; W. L. Dethloff, chief engineer; L. J. Ingolfsrud, assistant chief engineer; T. M. Paris, chief chemist; W. A. MacDonell, cashier; Frank Simms, purchasing agent. All reside at Coniston, Ont.

Coniston Smelter.—In 1921, as in the previous year, one furnace and one converter were kept in blast at the Mond Nickel Company's smelter.

The officers are: E. T. Austin, superintendent; K. S. Clarke, superintendent of sintering and flotation plants; John Grigg, master mechanic.

Coniston Quarry.—During the latter part of the year when the stockpile of siliceous ore from Bruce was nearing depletion, the Mond Nickel Company opened a quarry half a mile southwest of the smelter. The rock here is a quartzite and is being used for flux at the smelter.

Bruce.—In February, 1921, the Mond Nickel Company stopped all work at the Bruce copper mines. A total of 5,439 tons of siliceous copper ore was shipped from Bruce to Coniston smelter during the year.

Garson.—Garson mine shipped 41,658 tons of ore in 1921. Most of this came from the stopes between the fourth and sixth levels and a small quantity was obtained from between the third and fourth. About 70 men were employed.

Pump stations were cut on the 600 and 1,000-foot levels and a sump cut on the latter. A Blake and Knowles double-acting plunger pump, 12 inches by 4 inches by 12 inches stroke, was set up on the sixth level and now pumps the water to the surface. A similar pump will be put on the tenth level to pump to the sixth.

Capt. A. L. Sharp, Garson, Ont., is superintendent, and Chas. Caesar and Alex. Pollock, mine foremen.

Levack.—The ore shipped from the Levack mine in 1920, 42,813 tons, was all obtained from Nos. 34 and 54 stopes which are east of the shaft and between the second and fifth levels. Frank J. Eager, Levack, Ont., is superintendent; J. G. Harris was mine foreman until April when he resigned and was succeeded by William Shovel; William J. Serpell is master mechanic. The force consisted of 70 men of whom 35 were underground.

Victoria.—During 1921 22,684 tons of ore was shipped from this mine; this ore was stoped from the following parts of the mine: stope between the 1st and 3rd levels east of the shaft; 15th and 16th level floor pillars; stope between the 16th and 17th levels, finishing this stope; stope between the 17th and 18th levels. No development work was done. The working force numbered about 68.

W. J. Mumford, Mond, Ont., is superintendent.

Worthington.—Worthington mine shipments for 1921 totalled 28,289 short tons and the working force average about 65 men. Stoping was continued between the second and fifth levels, but no development work was undertaken. A. D. Carmichael, Worthington, Ont., is superintendent, and William McKerrow is mine foreman.

Iron Pyrites

Rand Consolidated.—Rand Consolidated Mines, Limited, has not worked its claims near Goudreau, Ont., since June, 1920, but early in 1922 stock in this company was again being offered for sale by Jackson and Jackson of Buffalo, N.Y.

The capitalization of the company is $5,000,000 divided into shares of $1.00 par value, and 4,100,000 shares have been issued. The directors are:—president, E. N. Ohl, Pittsburgh, Pa.; vice-president and treasurer, F. W. Powers, Pittsburg; Judge Charles A. Pooley, Buffalo, N.Y.; Dan Clemson, Pittsburgh; John M. Shaw, Indianapolis; Frank L. Danforth, Buffalo; Albert H. Jackson, Buffalo.

Miscellaneous

Gros Cap Mining and Exploration Company, Limited.—This company, which was incorporated on October 8, 1919, with a capital of $100,000, owns mining claims S.S.M. 2344 and S.S.M. 2345 and has an option on the south half of the northeast quarter of section 31 in the township of Prince; these holdings are situated at Gros Cap on the St. Mary's river about 12½ miles from Sault Ste Marie, Ont. The company has as yet done but little work.

The head office is at 270 Queen Street, Sault Ste Marie, Ont., and the directors are:—president, J. G. Dycie, Sault Ste Marie, Ont.; vice-president, William D. Clarke, Sault Ste Marie, Mich.; secretary, Florence M. Bonnin, 58 Pim Street, Sault Ste Marie, Ont.; S. Lightfoot, James C. Cheyne, and Robert McMann, all of Sault Ste Marie, Mich.

Shoefelt.—It was reported in September that a silver claim was being prospected near McLennan, Ont., not far from the Soo branch of the Canadian Pacific railway. The writer, therefore, visited the scene of the reported discovery on September 7. On land owned by Jacob Shoefelt in the north half of lot 4, concession II, township of Tarbutt, four men were sinking a prospect pit under the supervision of W. H. Todd of Welland. This pit, which was started some years ago, was 12 feet deep at the time of examination. It was in diabase and a few bunches of calcite carrying a little chalcopyrite had been encountered, but there was no vein visible in the pit at the time of inspection.

III.—DISTRICT OF TIMISKAMING

Gold

Boston Creek, Larder Lake, etc.

Miller-Independence.—Miller Independence Mines, Limited, had 25 men employed at its property in Pacaud township during the first quarter of the year. The force was then cut to 15 men and the work confined to cutting diamond-drill stations and diamond-drilling on the 500-foot level. A total of 1,600 feet of drifting and crosscutting has been done on this level.

W. E. Simpson, Boston Creek, Ont., is manager.

Canadian Associated Goldfields, Limited.—This company now controls Associated Goldfields Mining Company, Limited. The capitalization of the new company is $30,000,000, as compared with $5,000,000 in the old one. Four shares of the new stock were issued to shareholders in exchange for one of the old. The directorate remains as stated in the Thirtieth Annual Report of this Department.

In 1921 the company did the following work at the properties in the Larder Lake area:

At the Harris-Maxwell ("Block B"), diamond-drilling totalling 3,918 feet.

At the Kerr-Addison the 3-compartment shaft was sunk to 320 feet and stations were cut at 175 and 300 feet. Station-cutting amounted to 6,852 cubic feet: excavation for sumps, 1,089 cubic feet; and excavation for diamond-drill stations, 1,642 cubic feet. Between June 1 and October 1, 1921, 775 feet of crosscutting and 310 feet of drifting were completed. This was divided between the two levels as follows: on the 175-foot, 257 feet of crosscutting and 124 feet of drifting; on the 300-foot, 518 feet of crosscutting and 186 feet of drifting. Channel samples were cut in all the crosscuts and drifts as a check on the assays obtained during the previous year from diamond-drill cores. In connection with the prospecting of this property, two dwelling-houses were built on the adjoining Reddick claim, and a smithy, a pipefitting building, and a change house at the Kerr-Addison shaft. The Kerr-Addison was shut down in the last quarter of the year.

In September the company acquired the Costello property, adjoining the claim being tested by the Crown Reserve Mining Company, and built the following: a powerhouse, 18 feet by 50 feet, a 35-foot headframe, a blacksmith shop, a pump house, and a transformer house. The principal machines installed are a 680-cubic-foot Sullivan air compressor, driven by a 150-horse-power motor, and an electrically driven hoist; the latter was brought from the Harris-Maxwell. A 2-compartment shaft, begun November 1, was sunk to 118 feet. A level was established at 110 feet, and on this 100 feet of crosscutting and 20 feet of drifting had been completed at the end of the year. This crosscut passed through a few feet of gold-bearing porphyry. There was also 966 feet of diamond-drilling done on this property.

The company employed an average of 65 men during the year. George Gray was manager during the greater part of 1921 and the first quarter of 1922.

Argonaut.—Argonaut Gold, Limited, has a capitalization of $3,000,000 in shares of $1.00 par value. The company operates under a federal charter and has the following officers:—president, J. H. Rainville; vice-president, F. A. Labelle; directors, Lieut.-Col. Stark, A. Raymond, L. Peddy, and Wilfred Duguette; all of these officers live in Montreal. L. J. Marchand, 145 St. James Street, Montreal is secretary-treasurer, and J. W. Morrison, Dane, Ont., manager.

Mining was resumed on April 4, but the burning of the mill on April 29 necessitated the stoppage of underground work for six weeks while a new transformer house was being built and two 100-kilowatt transformers put in commission. The development work completed during the year consisted of 1,000 feet of drifting and 545 feet of crosscutting; nearly all of this was done on the 350-foot level. An average of 30 men was employed.

The shaft is now being continued from a depth of 380 feet to 500 feet.

Blanche Bay.—The Blanche Bay Syndicate has an office at 152 Livingston Avenue, Buffalo, N.Y., and consists of the following:—Dr. Baker, E. L. Moses, John Shaff, Henry Shaff, and George Walker. The syndicate owns claims L. 6973, L. 6974, and L. 8218 in Grenfell township near Kenogami station and in October and November sank a 22-foot shaft on one of them. Richard Haggerty was in charge.

Blue Quartz.—Blue Quartz Gold Mines, Limited, was incorporated in 1921 to acquire the property at Painkiller lake formerly worked by Cartwright Gold Fields, Limited. The new company has a capitalization of $3,000,000, and the officers are as follows:—H. C. Crow, Toronto, president; C. H. Taylor, Toronto, vice-president; J. F. Loudon, Toronto, secretary-treasurer; J. J. Hollinger, Matheson, Ont., manager. The head office is at 184 Sunnyside Avenue, Toronto.

In 1921 five men were employed at trenching and sinking pits, but in January, 1922, mining was begun with a force of sixteen men. A 100-foot shaft was sunk on one of the claims in 1915.

Crown Reserve.—The Crown Reserve Mining Company, Limited, began trenching in June on a group of claims in McVittie township about a mile and a half north of Larder Lake. This group consists of mining claims L.S. 191, L. 9032, L. 8713 and L. 8841. The trenches were from 40 to 120 feet in length. Those on the first two claims were timbered trenches with a depth varying from 12 to 20 feet; the third one of these trenches was lost by caving. A total of 1,146 feet of diamond-drilling was also done before the property closed down for the winter. H. J. Stewart was manager and about 15 men were employed.

Golden Summit.—The Golden Summit Mining Company, Limited, incorporated October 16, 1919, with a capital of $2,500,000, owns the Jensen farm, which is in the north half of lot 6, concession I, Maisonville township. J. T. Kerr, Windsor, Ont., is president and general manager, and the head office is in the Heintzman Building, Windsor.

In 1921 the company did a small amount of work, deepening a shaft to 27 feet.

Lightning River.—Lightning River Gold Mines, Limited, was incorporated on March 26, 1920, under the laws of Ontario and has an authorized capitalization of $3,000,000, divided into shares of $1.00 par value. The head office is in Guelph, Ont., and the directors are:—William J. Lucy, Haileybury, Ont., president and general manager; J. W. Morrison, Dane, Ont., first vice-president and consulting engineer; William M. Cochenour, Haileybury, Ont., second vice-president; Thomas McCallum, Montreal, Que.; Dr. R. Lucy, Guelph, Ont.; R. A. Treleaven, Palmerston, Ont.; Udney Richardson, Elora, Ont., secretary and treasurer.

The company is interested in 24 mining claims having a total area of 1,150 acres. All are in the Larder Lake Mining Division, twelve claims in Holloway township, two in Harker township and the remainder in the townships of Maisonville and Egan. The claims in Holloway and Harker townships are in the Lightning river area, twelve miles south of Upper Abitibi lake; the Maisonville claims are two miles from Sesekinika station; and the Egan claims are southwest of Matheson. The company has also acquired the Watabeag river waterpower in Currie township, three miles from the Egan township claims.

In December the Company commenced work on the Harker-township claims, Nos. 7247 (Cochenour) and 7463, and let a contract for the sinking of a two-compartment shaft to the depth of 50 feet.

Skead Gold.—The Skead Gold Mines, Limited operated until December 8, 1921. A dozen men were employed in winter and six in summer with M. L. Bouzan as superintendent.

Two shafts, each 50 feet in depth, and one 18 feet were sunk on lot 29 near Skiddoo lake. On lot 30, twenty-two test pits were sunk from 5 to 18 feet in depth. On the group of claims west of St. Anthony lake three test pits were sunk 8, 15, and 22 feet deep, and on the group of claims east of St. Anthony lake 14 test pits were sunk varying from 8 to 20 feet deep.

Porcupine

Beaumont.—The Beaumont Gold Mines, Limited, has the following officers:—R. T. Jeffrey, president; L. G. Harris, managing director, Royal Bank Building, Toronto; S. H. Allen, manager, South Porcupine. The property of this company is in concession VI, Tisdale township.

In 1921 the shaft was sunk from a depth of 54 feet to 320 feet, and levels established at 150 and 300 feet. Lateral work consisted of 750 feet of crosscutting and 47 feet of drifting. After mining was stopped in the autumn, 3,000 feet of diamond-drilling was done.

A transformer house, an assay office, and a stable were added to the company's buildings. Transforming equipment and a 10-inch by 12-inch hoist were obtained from the Dome Lake mine.

Big Dyke.—The Big Dyke Gold Mines, Limited, had three men employed during the summer and drove an adit 115 feet in length. The property of this company is in Ogden township, half a mile north of the Hayden mine.

Dome.—The authorized capital of the Dome Mines Company, Limited, has been reduced from $5,000,000, to $4,500,000, (as at March 31, 1922) by the payment to shareholders of $1.00 per share. Of the capital stock, $4,260,879.00 has been issued; $29,124.00 has been allotted but is not issued; $209,997.00 remains in the treasury.

The executive officers of the Company are: Jules S. Bache, New York City, president and treasurer; W. S. Edwards, Chicago, first vice-president; H. P. DePencier, South Porcupine, second vice-president and general manager; Morton F. Stern, New York City, third vice-president; Alex. Fasken, Toronto, secretary; C. W. Dowsett, South Porcupine, general superintendent. The directors are: Jules S. Bache, New York City; W. S. Edwards, Chicago; Alex. Fasken, Toronto; G. C. Miller, Buffalo, N.Y.; T. R. Finucane, Rochester, N.Y.; Howard Poillon, New York City; Frederick G. Corning, New York City; Morton F. Stern, New York City; The head office of the Company is at 36 Toronto Street, Toronto, and the executive and financial office at 42 Broadway, New York City.

The following information is an abstract from the eleventh annual report of the Company covering the year ending March 31, 1922:

> Four dividends of 25 cents per share were declared during the year, the last, No. 18—being payable April 20, 1922. The net excess of current assets over current liabilities amounts to $1,758,165.00.
>
> Stoping and development have been carried on from the fifth to the tenth levels and in addition the main shaft has been sunk 263.5 feet to a point 58.5 feet below the twelfth level. Sinking is being continued and the shaft will be below the thirteenth level in May, 1922. Development work has been started on the eleventh level.

The improvement in labour and operating conditions has permitted an increase in the broken ore reserve amounting to about 70,000 tons, the broken ore reserve now standing at 275,000 tons. This result compares very favourably with last year's operating when the broken ore reserve was depleted by 50,000 tons. The cost of breaking this additional tonnage is included in the operating cost, and has to be taken into account when considering efficiency and costs. It is estimated that to obtain a normal operation and maximum efficiency we should have at least 350,000 tons in the broken ore reserve, and it is expected that this position will be reached before the end of the present year.

The results of the development work during the year were very satisfactory, more particularly on the eighth level to the west and on the tenth level to the west. Diamond-drill holes have shown that this ore body continues to the twelfth level, which is 300 feet below the tenth.

The only work done in Dome Extension ground during the year was a small amount of stoping in the sixth level ore body; from this stope 6,510 tons, averaging $4.71 per ton were drawn. It is expected that important ore bodies will be developed in Dome Extension on the eleventh and twelfth levels during the coming year.

The expenditure on mining was $556,299.05 or $1.545 per ton milled as against $1.256 per ton milled during the last year. The increase is due to the fact that 70,000 tons more was broken than was milled, as against 50,000 tons less broken than milled in the 1920-21 year. There has also been a much greater area of stope sill cut during the past year.

The expenditure on development was $404,171.27 or $1.123 per ton milled; this includes 263.5 feet of shaft sinking in No. 3 shaft. The heavy development expenditure was largely necessitated by the fact that the more important ore bodies are situated 450 feet to 900 feet from the shaft, thus requiring long drifts and crosscuts to reach the zones to be prospected.

The following table gives particulars of the development work:

Level	Shafts and Winzes	Drifts	Crosscuts	Crosscuts Slabbing	Raises	Raise Slabbing	Box Holes	Stations and Miscell.	Total	Diamond Drilling
3rd		57					40		97	532.33
5th		39	167	32	316		92		646	1,014.00
6th		11	21	3	20		86		141	1,097.91
7th		808	51	98	567	153	330		2,007	3,542.00
8th		1,050	740	251	438	36	489	40	3,040	3,101.07
9th		1,167	416	67	15		4		1,669	1,503.00
10th	156	928	731	129	920	25	725	32	3,646	6,716.33
11th	196.5	415	25	10				195	841.5	
12th	67	17						88	172	
Totals	419.5	4,492	2,151	590	2,276	214	1,766	355	12,263.5	17,506.64

Waste hoisted, 45,036 tons.

The ore bodies opened up during the year, as formerly, have proven so irregular in form and mineral content that no satisfactory estimate can be based on the exposures in drifts and crosscuts. Only by experience in actual stoping operations can we form any definite idea of what tonnage may reasonably be expected from a given exposure, and the law of averages must be depended upon in the final result.

While production of the last year has been the greatest in the history of the mine by 29 per cent., we are confident that the extensive development policy adopted has been successful in placing an equivalent amount in sight, and we can therefore look forward confidently to similar results from our future operation.

The following are the treatment results from the operation of the mill during the year:—

		per ton	per cent.
Heads, 360,000 tons		$8,203	.....
Amalgamation bullion	$1,622,012 48	4,506	54.924
Cyanidation bullion	1,187,439 90	3,298	40.209
	$2,809,452 38	7,804	95.133

Of the 360,000 tons of ore milled 333,081 tons, averaging $8.65 per ton, came from the stopes and 26,919 tons, averaging $10.16 came from development.

The total milling cost was $445,703.38, or $1.238 per ton treated. The cost for the previous year was at the rate of $1.563 per ton. The following factors were responsible for the reduced cost; the increase in the tonnage milled, the somewhat lower cost of some supplies such as iron and steel, and the reduction in the wage rate. These savings were to some extent offset by the expense incurred by finer grinding and longer treatment of the ore. The extraction was 95.13 per cent. as against 94.728 per cent. for last year. The finer grinding, already referred to, became necessary owing to the rock from some of the ore bodies showing a tendency to give a reduced extraction with ordinary fine grinding. At present the ore is ground so that 92 per cent. passes a 200-mesh screen, a degree of fineness surpassed by only a few mines treating exceedingly rebellious ores. Longer cyanide treatment, as well as finer grinding, has been found necessary, and this is being provided for by the addition of two more Pachuca tanks, which will increase the time of treatment by thirty per cent.

Both the re-grinding tube mills have been equipped with special liners and iron balls to improve the fine grinding of concentrate. Two Pachuca tanks have been in operation since completion early in the year, and two more will be completed and in operation early this year.

Expenditure on increase of plant amounted to $55,969.86, of which $7,048.00 was written off. A third 2,500-cubic-foot Belliss and Morcom compressor has been ordered and will be installed early in the year; this compressor was ordered in 1916, but war conditions prevented shipment. The buildings at Dome Extension have been converted into dwellings, thus providing eight more houses for employees. The new hospital to replace the one burned was completed early in the year.

Operating costs amounted to $4.558 per ton milled, as compared with $4.529 for the previous year. This increase is more than accounted for by the increased expenditure on development work, this expenditure amounting to $1.123 per ton milled, as against $0.925 for the former period. There is also an increase of 70,000 tons in broken ore reserve, as against a reduction of 50,000 tons in the previous year.

An ample supply of labor has been available throughout the year and a reduction of six cents per hour has been made in wage rates.

Goldale.—Goldale Mines, Limited, has bought from The Ontario Porcupine Goldfields Development Company, Limited, the fifty claims formerly owned by Bewick, Moreing and Company: The company has a capital of 3,000,000 shares of $1.00 par value, and 1,751,421 shares have been issued. The directors of the company are as follows:—James Y. Murdoch, Toronto, president; H. W. Knight, Toronto, vice-president; Arthur H. Britton, Toronto, secretary-treasurer; T. H. Rea, New York; and R. V. LeSueur, Sarnia. The head office is at 85 Bay St., Toronto.

In 1921 the work done consisted of trenching, sampling, and the sinking of five diamond-drill holes totalling 2,503 feet.

Kerr Lake Mines, Limited, has bought a large block of the company's treasury stock and in April, 1922, H. A. Kee took charge of the work.

Hayden.—Hayden Gold Mines, Limited, had a capitalization of $2,000,000, but at the last annual meeting a reorganization was effected and the capitalization increased to $5,000,000. W. H. Hayden is president and general manager; W. H. Hills, vice-president; and Willis M. Spaulding, secretary and treasurer. The head office of the company is at 509 Brisbane Building, Buffalo.

The mine was pumped out in October and mining resumed late in December with a force of twelve men. Thirty feet of drifting was done before the end of the year.

Hollinger.—The Hollinger Consolidated Gold Mines, Limited, has an authorized capital of $25,000,000—5,000,000 shares of $5.00 par value each; 4,920,000 of these shares are outstanding. The officers of the company are: Noah A. Timmins, president; David A. Dunlap, vice-president and treasurer; John B. Holden, secretary; A. F. Brigham, general manager. The directors are: Noah A. Timmins, L. H. Timmins, Jules R. Timmins, and Dr. Wilfred L. McDougald of Montreal; David A. Dunlap and John B. Holden of Toronto. The mines and head office are at Timmins, Ont., and the general office is at 85 Bay Street, Toronto.

The following account of the year's operations is summarized from the eleventh annual report of the company, covering the year ending December 31, 1921:

The yield from 1,072,493 tons milled in 1921 was $10,031,050.57. Total income from all sources was $10,314,515.31. Operating expenses absorbed $5,222,855.69, taxes $429,889.61, depreciation, etc., $634,842.52, making $6,287,587.82 in all, and leaving a net profit of $4,026,927.49; out of the latter $3,198,000.00 was paid in dividends and $828,927.49 added to surplus, which now stands at $3,960,779.50.

Following is a summary of charges per ton of ore milled:—

	Sundries.	Labour.	Stores.	Total.	Per ton milled.
General charges.....	$110,163 71	$228,924 69	$120,739 39	$459,827 79	$0.4287
Mining charges.....	....	1,979,817 73	1,215,026 71	3,194,844 44	2.9789
Milling charges.....	....	500,891 00	1,067,292 46	1,568,183 46	1.4622
Grand Total....	$110,163 71	$2,709,633 42	$2,403,058 56	$5,222,855 69	$4.8698

Expenditure charged to plant account for buildings and equipment during the year was $482,790.79, and the amount written off was $627,488.50. Plant account now shows a total expenditure from 1910 to the end of 1921 of $4,183,256.76 and $2,827,954.47 written off during that period; the present valuation is 32.4 per cent. of the total cost of the plant, as compared with a valuation of 40.5 per cent. at the end of 1920.

The company's property has been augmented by the construction of 150 cottages for employees on the Jerome addition to the town of Timmins. This work involved a further expenditure for clearing the land, the laying of water service and sewers, streets, and electric-light equipment.

At No. 11 shaft a large and well-equipped change house to accommodate 800 miners has been built and put in use; also the old change house at the main shaft has been replaced by one designed to serve 600 miners. These buildings are well-lighted, warm, dry and equipped with individual steel lockers, wash-basins, showers and modern sanitary conveniences. A new building to centralize drill sharpening and tempering has also been completed with facilities for handling 9,000 drills per day.

As to power, the compressor plant now comprises three units of 4,500 and one of 9,100 cubic feet capacity, equal to 22,600 cubic feet of free air per minute. Two of the smaller compressors are so designed that, by making some minor changes, they can be converted into steam engines, and the motors that drive them operated as generators. This arrangement is novel and was adopted to ensure the continuous operation of the cyanidation machinery in the event of breakdowns, but it is not intended that the plant shall function in the reversed condition for a longer time than is necessary to make repairs to the power company's machinery or transmission lines. Notwithstanding this fact, two units were operated continuously from the middle of December, 1920, to April 7, 1921. This provided about 1,200 horsepower which, with the 1,500 kilowatts allotted by the power company, constituted the entire supply of electric power, as compared with 8,100 horsepower used and paid for during the latter part of the year. Work was adjusted to the reduced scale, and costs mounted to a figure never before reached by the Hollinger. From April 7 they declined, and toward the end of the year, as the mill feed increased, were approaching normal, but they are still higher than the figures for the year 1920.

In the mine a new vein was discovered on the 200-foot level; it is numbered 92 and is of good grade and width. The rest of the ore bodies have maintained their value and size.

Drifting and crosscutting was continued throughout the year at such a rate as to provide for the immediate stoping requirements, and maintain the ore reserves at about the same figure as shown in the preceding three years. The policy of the company is to so adjust the development programme that the ore put in sight will, with a safe margin, approximate the tonnage milled. This will continuously tie up $1,750,000 and will ensure a three and a half years' supply of ore at the present rate of milling.

The development work done during the year was as follows:

Level	Shafts	Drifts	Cross Cuts	Raises	Diamond Drilling	Timbering		Excavation
						Shafts	Stopes	
	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Tons
100 feet	......	....	....	....	1,321	....	....	....
200 feet	......	1,690	494	325	6,786	....	333	....
300 feet	......	1,444	244	567	3,557	....	1,210	....
425 feet	......	1,787	1,361	408	6,520	....	1,212	....
550 feet	......	1,820	700	...	5,600	....	1,332	....
675 feet	......	4,884	3,859	...	6,588	....	3,549	....
800 feet	......	4,792	1,467	...	5,661	....	1,348	131
950 feet	......	140	2,341	...	525	....	....	....
1,100 feet	10	204	1,617	337	1,059	....	....	75
1,250 feet	166	....	800	136	.....	....	....	115
Total....	176	16,761	12,883	1,773	37,617	....	8,984	321

Total, Sinking, Drifting, Cross-Cutting and Raising, 31,593 ft.

Details regarding the broken ore:

Level	Broken Ore in Mine Jan. 1, 1921	Ore Broken During 1921	Ore Removed During 1921	Broken Ore in Mine Dec. 31, 1921
No. 10 Shaft Dump	2,250	....	....	2,250
Above 200 ft. Level	56,096	113,868	108,338	61,626
" 300 ft. Level	34,264	101,449	99,630	36,083
" 425 ft. Level	77,716	182,218	131,143	128,791
" 550 ft. Level	232,908	380,435	470,856	142,487
" 675 ft. Level	660	206,803	136,363	71,100
" 800 ft. Level	91	207,295	119,840	87,546
" 950 ft. Level	....	1,466	1,466	....
" 1,100 ft. Level	....	1,244	1,244	....
" 1,250 ft. Level	....	1,074	1,074	....
Total	403,985	1,195,852	1,069,954	529,883

The ore developed underground as of December 31, 1921, was:

Above 425-foot level—1,408,314 tons valued at $15,012,250
425 to 800-foot level—1,712,571 tons valued at $18,721,478
Below 800-foot level— 281,724 tons valued at $ 2,910,426

A total of 3,402,609 tons valued at $36,644,154

A summary of ore reserves follows:

	Tons	Value per ton	Estimated gross value Dec. 31, 1921.	Estimated gross value Dec. 31, 1920.
Veins over $10.00	1,571,979	$12 80	$20,127,764	$19,825,861
Veins, $10.00 to $8.00	1,653,969	9 15	15,138,440	15,697,762
Veins, $8.00 to $6.00	176,661	7 80	1,377,950	1,072,436
Total ore reserves	3,402,609	10 77	$36,644,154	$36,596,059
Probable ore—				
Veins under $6.00	787,668	5.28	$4,162,833	3,135,731
Surface outcrops	202,640	9 42	1,909,040	1,987,880
Total	4,392,917	$9 72	$42,716,027	$41,719,670

Certain minor changes in the coarse-crushing machinery have resulted in an increase in the tube mill output, and established the capacity of the whole plant at 4,000 tons, or more, per day; this average can be confidently expected for the coming year.

Following is a statement of the milling results:

Tons ore milled	1,072,493
Average value per ton	$ 9 67
Gross value	$10,367,901 07
Deduct loss in tailing	$ 336,850 50
Net value recovered	$10,031,050 57

Average tons per day	2,938 tons	Cyanide consumed per ton of ore	0.521 lbs.
Per cent. of possible time run	78.7	Zinc consumed per ton of ore	0.209 lbs.
Tons per 24 hours running time	3,733 tons	Zinc consumed per ton of solution	0.100 lbs.
Stamp duty per 24 hours running time	16.59 tons	Lime consumed per ton of ore	2.406 lbs.
Solution precipitated per ton ore	2.08 tons	Lead acetate per ton of ore	0.012 lbs.
Value per ton in tailing	$0.31	Average value pregnant solution	$4.48

The average number of men employed during the year has been 1,582, distributed as follows:—

Miners.		Mechanics.		General.		Total.	
Exploration	11	Operation	72	Mill & refinery	182	Miners	1,003
Development	203	Maintenance	141	Engineering staff	39	Mechanics	218
Production	789	Construction	5	Clerical staff	29	General	361
				Miscellaneous	111		
	31,00		218		361		1,528

The number of stockholders has increased from 2,800 to nearly 3,500.

McIntyre.—The ninth annual report of McIntyre Porcupine Mines, Limited, covering the fiscal year ending June 30, 1921, is summarized below:—

Brig. Gen. Sir Henry M. Pellatt, C.V.O., has retired from the directorate and has been succeeded by W. J. Sheppard of Waubaushene as vice-president, and by Joseph Errington of San Francisco as director.

Net operating earnings before providing for taxes and depreciation amounted to $815,562.53 and non-operating revenues to $272,951.38 or a total of $1,088,513.91. This is a decrease of $191,718.46 in total earnings from the previous year and is due to a curtailment of work from December 26, 1920, to April 7, 1921, caused by a shortage of power. To guard against a similar shortage, the company has acquired the right to develop Sturgeon Falls on the Mattagami River, thirty miles from the mine. Of the total earnings, $272,983.79 was appropriated as follows:

Reserve for plant depreciation	$207,326 50
Reserve for taxes for the current year	64,525 54
Written off holdings in adjoining mining properties	1,131 75

This left a net profit for the year of $815,530.12.

As in the previous year, three dividends of five per cent. each and aggregating $546,042.45 were paid to the shareholders. The surplus now amounts to $1,646,207.76.

During the year, there was treated 171,916 tons of ore having an average value of $11.67 per ton; this yielded bullion containing 91,330.26 ounces of gold and 19,806.4 ounces of silver, valued at $1,904,326.36; a recovery of $11.08 per ton of ore treated.

The total ore hoisted was 174,030 tons, of which 153,267 tons was obtained from stopes and development headings and the remainder from broken ore reserves. There are now 92,748 tons of ore broken in the stopes.

Following is a summary of ore hoisted:

Level	Tons	Assay value	Total value
600	2,138	$ 7 00	$ 14,966 00
700	1,623	9 25	15,012 75
800	4,433	14 75	65,386 00
1,000	47,731	13 85	661,074 35
1,125	53,022	9 85	522,266 70
1,250	31,356	14 15	443,687 40
1,375	30,565	9 15	279,669 75
1,500	3,162	9 00	28,458 00
	174,030	$11 58	$2,030,520 95

Development work done during the year was confined to the 1125-, 1250-, 1375-, and 1500-foot levels. The carbonaceous schist encountered in the lower levels of the mine occurs in a series of south-dipping thrust faults intersecting No. 5 vein for a distance of 350 feet on the 1250, 420 feet on the 1375 and 435 feet on the 1500. Drifting in this faulted zone opened up sections of No. 5 vein of good stoping width, but, in mining, this ore will be diluted with carbonaceous material requiring special treatment before cyanidation. Considerable development has been carried on to the west and below the carbonaceous zone of the four lower levels, and on each level No. 5 vein has been found to continue below the zone without any marked change of gold content, three stopes now producing ore from this section assay from $13.00 to $16.40.

Below the 1250-foot level the contact between the greenstone-basalt schists and the porphyry, which strikes southwest, flattens out and the area of favorable ore-bearing formation is increased.

The main shaft is being sunk from the 1500-foot level and is now 1610 feet deep. Levels will be opened at 1625, 1750 and 1875 feet. No. 5 shaft is being raised from the 1375 to the 1000, and when completed will be sunk to the 1500-foot level to facilitate the development of the lower levels.

Development and exploration work to 30 June, 1921, are summarized as follows:—

Drifts	41,575.8 ft.
Cross-cuts	15,243.3 "
Raises	6,499.4 "
Winzes	579.7 "
Shafts	5,697.4 "
Stations	1,459.0 "
Sumps	2,542.0 tons
Pockets	3,764.0 "
Total Footage	71,054.6 ft.
Excavations	6,306.0 tons
Diamond Drilling	49,319.0 ft.

The total operating costs per ton milled amounted to $6.3331. Mining costs totalled $3.5711, made up of: breaking and stoping $2.3004, development $1.1728 and exploration $0.0979. The other items are: milling $1.2052, crushing and transportation of ore $0.2317, head office expense $0.4461, mine office expense $0.3592, employees' insurance and welfare, $0.2569, heating and maintenance of buildings, $0.1683, general insurance $0.0866, examination of prospects $0.0080.

The ore reserves are estimated as follows:

	Tons	Assay	Amount
McIntyre claims	224,586	$10 55	$2,366,524 00
McIntyre Extension claims	205,007	10 50	2,153,981 00
Jupiter claim	102,081	7 95	813,275 00
Broken ore reserves in stopes	92,748	11 40	1,058,614 00
	624,422	$10 25	$6,392,394 00

A process has been developed that will satisfactorily treat the ores containing carbonaceous matter without the aid of flotation. After a preliminary treatment in the ball and tube mill circuit, the ore can be safely sent to the cyanide plant without danger of causing a premature precipitation of the gold. The milling capacity of the plant will be increased to 1,000 tons per day by the addition of a 500-ton unit equipped to handle carbonaceous ores.

The mill ran 85.5 per cent of the time, and treated 171,916 tons of ore at a cost of $1.2052 per ton with an extraction of 94.9 per cent.

Northcrown.—The directors of the Northcrown Porcupine Mines, Limited, decided early in the year to develope and diamond-drill the Thompson-Krist section of the property. Up to June 7, 2,000 feet of drifts and crosscuts were driven and 1,500 feet of diamond-drill holes completed. During the remainder of the year only a small crew for pumping and maintenance was employed.

Porcupine Davidson.—Porcupine Davidson Gold Mines, Limited, has succeeded Davidson Consolidated Mines, Limited, as owner of the 420 acres known as the Davidson mine. The price paid for the property was £50,000 cash, £175,000 preferred stock, and £450,000 common stock. The capitalization of the new company is £1,000,000, in shares of five shillings each, and £710,044 has been issued. The directors are: Colonel Robert Starke, Montreal, Que.; H. H. Sutherland, Toronto; Arthur Wilson Filmer, London, Eng.; Sir Archibald Mitchelson, Bart., London, Eng.; The Hon. Inigo Brassey Freeman Thomas, London, Eng.; Robert Fennell, Toronto; J. J. Davis, London, Ont. R. E. Evans, 4 King Edward Hotel, Toronto, is secretary-treasurer.

The mine was pumped out in September, and 45 men, exclusive of ten diamond-drill operators, were employed between October and December 12. The development work done consisted of: 74 feet of crosscutting north and 140 feet west in ore on the 600-foot level; a 49-foot raise, connecting the 600-foot with the 550-foot level, and 100 feet of crosscutting to the south from the top of the raise.

Four thousand feet of diamond-drilling was done from the 600-foot level; this showed commercial ore at a vertical depth of 725 feet. One 600-foot and two 1000-foot holes were drilled from the surface, and two more 1,000 foot holes are being put down to cut the ore at a depth of 1,000 feet; when this drilling is completed, the ore body will have been tested for a length of 1,500 feet.

Porcupine Peninsular.—The Callinan-McKay Exploration Company (A Delaware incorporation) began work in August, under a working option on the properties of the Porcupine Peninsular Gold Mines, Limited, The latter is an Ontario Company with a capital of $1,000,000 and owns Gold island and a portion of the peninsula in Night Hawk lake; the original board of directors consisted of: J. H. Black, C. M. Auer, J. A. McKay, George Grover and Frank Forbusch. On March 24, 1922, Night Hawk Peninsula Mines, Limited, was incorporated with a capital of $5,000,000 and acquired the assets of both the above-mentioned companies together with some additional mining claims. The officers of the new company are: William Thaw, president; J. W. Callinan, vice-president; J. A. McKay, vice-president; Samuel J. Grenet, Treasurer; Sam. Hallis; James R. Dodworth, chairman board of directors. A. R. Globe is manager and from twenty to thirty men are employed.

The property has an area of 266 acres and comprises 7 claims in two groups, namely; Nos. 914 to 919, and P. 7801.

There was an 80-foot shaft on the end of the peninsula. This was deepened by 110 feet and a second level opened at 180 feet. Lateral development in 1921 consisted of 11 feet of crosscut and 29 feet of drift. Subsequent drifting has given very encouraging results, and in the west drift on the 180-foot level a face of 24 feet of $14.00 ore has been opened up.

Porcupine Keora.—Porcupine Keora Mining Company, Limited, had 15 men at work during the first seven months in the year and kept the mine pumped out until October 15, when it was allowed to fill with water.

The development work consisted of 80 or 90 feet of drifting in graphitic ore, 30 feet of drifting on No. 11 vein and 390 feet of crosscutting south on the 245-foot level to cut Nos. 1 and 3 veins. J. C. Waite is manager.

Triplex.—The Triplex Gold Mines, Limited, capitalized at $5,000,000 in shares of $1.00 par value, was formed to work 29 mining claims in Shaw and Langmuir townships. The holdings aggregate 1266 acres and include the Tommy Burns, Cavanagh, Pope, and other claims. The officers are:—Charles B. Post, Worcester, Mass., president; Andrew G. Hildreth, Worcester, Mass., first vice-president; Gordon H. Gauthier, South Porcupine, Ont., second vice-president; Matthew Thomas, South Porcupine, Ont., secretary-treasurer; Charles S. Averill, Worcester, Mass., director; William H. Dalton, Toronto, director; William M. Moore, Toronto, director; Major Duncan B. Harrison, Hotel Bancroft, Worcester, Mass., construction manager and fiscal agent.

The company started work in June on the Burns claims, sank 105 feet of incline shaft, and on the 100-foot level did 30 feet of drifting to the north and 37 feet to the south. The force consisted of 20 men.

Union.—The Union Mining Corporation, Limited, continued to prospect in Whitesides township until December 10, when it was decided to stop work at the property there and exploit the Smith-Labine claims, a 120-acre property near Sesekinika. The company has been changed to a common-law business trust, the Union Gold Mines Trust, with a capital of $2,000,000 in $10.00 shares.

The underground work completed at the Whitesides township prospect consisted of: a 260-foot shaft with levels at 150 and 250 feet; on the 150-foot level, 230 feet of crosscutting and 100 feet of drifting; on the 250-foot, 130 feet of crosscutting. From 25 to 30 men were employed under manager C. T. Denker, Timmins, Ont.

Kirkland Lake

Bidgood.—The Bidgood Gold Mines, Limited, had thirty men employed on its property in Lebel township during the last seven months in the year. George Tough is president, and D. H. Angus, manager.

Development work consisted of drifting on the 300-foot level, mainly on No. 9 vein, sinking the shaft from the 300 to the 400-foot level, and crosscutting on the 400-foot level to cut No. 9 vein. The following summary shows the amount of work accomplished underground during 1921 and to date:—

	1921.	Total.
Drifting	633 feet	1041 feet
Crosscutting	308 feet	657 feet
Shaft sinking	100 feet	417.5 feet
	1041 feet	2118.5 feet

King Kirkland.—The King Kirkland Gold Mines, Limited, has an authorized capital of $2,500,000 of which 1,250,000 shares have been issued, and 1,250,000 remain in the treasury. The board of directors is as follows:—C. F. Jordan, Haileybury, Ont., president and general manager; E. L. Wettlaufer, Toronto, Ont., vice-president; A. B. Crosby, Treasurer; G. A. M. Davidson, secretary, (Clerk of Markham township); George I. Hambly, Toronto, and John Schwartz, Kitchener.

The company owns 7 mining claims, L.8001, L.8002, L.4117, L.4118, L.2292, L.2910, LS.108, in one block of 309 acres in Lebel township east of Gull lake. Twenty men were employed during the summer under the supervision of Ernest Craig. The work done consisted of considerable trenching, the sinking of a 100-foot shaft and a little drifting.

Kirkland Combined.—On December 1, 1921, the Kirkland Combined Mines, Limited, resumed drifting on the 200-foot level. Work was in progress for two months, during which 300 feet were driven and a 600-foot diamond-drill hole put down. Ten men were employed in the mine, five of whom were diamond-drill workmen. A. W. Grierson is superintendent.

Kirkland Lake.—The Kirkland Lake Gold Mining Company, Limited, has a paid-up capital of $2,000,000, the par value of the shares being $1.00.

The directors of the company are:—F. L. Culver, president; W. T. Mason, vice-president; R. Graham, secretary-treasurer; F. L. Lovelace. The head office of the Company is at 810 Lumsden Bldg., Toronto. W. M. Sixt is mine superintendent.

The sixth annual report of the company covers the period for the seven months ending December 31st, 1921. The development work during this period was as follows:—drifting, 1043 feet; crosscutting 163 feet; raising 148 feet; shaft raising 77 feet; shaft sinking 15 feet; diamond-drilling 1,001 feet. The main or central shaft is now at the 700-foot level. The mill treated 25,717 tons of ore from which was recovered $147,654.83 in gold bullion.

Lake Shore.—The Lake Shore Mines, Limited, has a capitalization of 2,000,000 shares of a par value of $1.00. The executive officers are:—Harry Oakes, president and managing director; W. H. Wright, vice-president; J. B. Tyrrell, second vice-president; Dr. W. P. St. Charles, treasurer; Kirkland Securities, Limited, secretary. The directors are Harry Oakes, A. G. Slaght, Dr. W. P. St. Charles, C. E. Wettlaufer, Albert Wende, J. B. Tyrrell, W. H. Wright. R. C. Coffey is mine manager.

For the year ending Nov. 30, 1921. 21,681 tons of ore were milled, from which was recovered in bullion $460,186.37, or $21.22 per ton. A total of 3,188 feet of development work was done during the year and the broken ore in stopes amounts to 28,298 tons. The shaft was sunk to the 600-foot level and No. 1 and No. 2 veins were opened up on this level.

Future plans include enlarging the shaft from the 400-foot level to the surface, sinking to the 800-foot level and increasing the milling capacity.

Three dividends of $40,000 each were paid during the year.

Montreal-Kirkland.—In November, 1921, the Montreal-Kirkland Mines, Limited, began work with a force of eight men on its 200-acre property, which is north of the Ontario-Kirkland mine. The camps were repaired and the following erected: a transmission line, a power house. 24 feet by 36 feet, a 47-foot head frame, a blacksmith shop and a stable. B. G. Killoran was in charge.

The company had a capitalization of $2,500,000. The board of directors is as follows: W. F. Empey, president; John T. Tebbutt, vice-president; A. A. Mack, secretary; Senator N. Curry, Robt. Curry, F. J. Hodgson, J. B. Peloquin, Fred Cooper, T. H. Reider, all of Montreal, and B. G. Killoran of Haileybury. The head office of the company is at 46 Bank of Ottawa Building, Montreal.

A merger with the Ontario-Kirkland Gold Mines, Limited, was effected March 10, 1922. The agreement provides for the formation of a new company known as the Montreal-Ontario Mines, Limited, with a capital of $5,000,000 in shares of $1.00 par value. The Ontario-Kirkland shareholders are to receive 1,500,000 shares in the new company equivalent to their capital stock, and the Montreal-Kirkland shareholders are to receive 1,725,000 shares in the new company, the equivalent to their issued stock. The new company assumes the current liabilities of the Ontario-Kirkland Mines, Limited, amounting to not more than $120,000, and in addition agrees to issue 481,250 shares of stock to provide for the payment of the present outstanding notes of the Ontario-Kirkland company amounting to $173,250.00; it further agrees to issue additional shares at 40 cents to cover the six per cent. interest on these notes.

The officers of the new company are: president, W. F. Empey; vice-president, Frank Huth; secretary-treasurer, A. A. Mack; directors: Albert J. Bolton, Hon. Daniel Curry, Walter E. Hurd, Robert Curry, W. H. Meyer, J. B. Peloquin, John T. Tebbutt.

Ontario-Kirkland.—The Ontario-Kirkland Gold Mines, Limited, operated its property at Kirkland Lake during the year with an average force of about 40 men; the force was increased to 70 men when the mill was put in operation about the end of the year. The company has a capitalization of $1,500,000 in shares of $1.00 par value.

The officers are: Frank Huth, president; Walter E. Hurd, vice-president; Albert J. Bolton, treasurer; W. A. Gordon, secretary; Ralph Hurd, manager.

The development work during the year consisted of 50 feet of crosscut on the 300-foot level, and 1,500 feet of drifts and crosscuts on the 450-foot level. The No. 2 shaft was completed to the 450-foot level by sinking from the surface and raising from the bottom level. Development from the No. 2 shaft consisted of 150 feet of crosscuts and 150 feet of drifts on the 150-foot level.

Stoping was begun in the last quarter of the year, and the No. 317 stope was carried up 40 feet over a length of 125 feet; the No. 302 stope was carried up 30 feet over a length of 175 feet. On the 150-foot level a small stope was carried up 20 feet over a length of 60 feet.

The additions to plant included the construction of a 100-ton mill complete for cyanide treatment; the installation of an additional air compressor of 1046-cubic-feet capacity driven by 170 h.p. motor, and an Ingersoll-Rand double-drum hoist driven by a 50 h.p. motor.

The mill was started in December, but two breakdowns of the hoist caused a month's delay. Between 3,000 and 4,000 tons were milled before the property was closed down, February 18.

Queen-Lebel.—The Queen-Lebel Gold Mines, Limited, has an authorized capital of $2,000,000 in shares of $1.00 par value; 1,000,000 shares have been issued and 1,000,000 remain in the treasury. The board of directors is as follows: G. A. Wanless, president; David Gross, vice-president; V. H. Hattin, secretary; Harry Braniff, treasurer; W. H. Hamblin and William T. Sass, all of Kitchener, Ontario, and E. B. Wood, general manager, Haileybury, Ontario. The head office of the company is at 35 King St. West, Kitchener, Ontario.

The company owns a group of four mining claims south of the east end of Gull Lake in Lebel township. The property contains 136.7 acres.

Trenching began on May 23, 1921, and about 3,000 lineal feet of this work was done during the summer with a force of 10 men. A 60-foot shaft was sunk by hand during the first quarter of 1922.

Camps and a power house were built and the following machinery installed in the spring of 1922: two 50-h.p. boilers, a 420-cubic-foot Ingersoll-Sargeant air compressor and a 7 by 9-inch hoist.

Teck-Hughes.—Teck-Hughes Gold Mines, Limited, operated its property during the year. The board of directors is as follows: Charles L. Denison, president; Albert W. Johnston, vice-president; George C. Miller, secretary; William C. Himrod, treasurer; Robert W. Pomeroy, J. F. Thompson. D. L. H. Forbes, Kirkland Lake, Ont., is general superintendent. An average of 75 men was employed.

The general superintendent's report for the fiscal year ending August 31, 1921, gives the following summary of operations:

During this period 32,634 dry tons of ore were treated from which bullion amounting to $304,792.33, or $9.34 per ton, was recovered. Including exchange, premiums and interest, the gross revenue for the year was $344,806.44, or $10.57 per ton. The total operating cost, including such indirect charges as depreciation on plant, new construction and extraordinary expense, amounted to $291,956.07, or $8.95 per ton, leaving a net revenue of $52,850.37. A detailed analysis of operating costs shows that the total direct operating cost amounted to only $7.01 per ton.

The first, third and fifth levels were extended and the sixth level started. Development work produced 3,935 tons of ore, that was treated in the mill, 587 tons of low grade rock, that was sent to stock piles, and 4,372 tons of waste. The total amount of development work was 1,792.8 lineal feet as detailed in the summary below.

	Winzes	Raises	Drifts	Crosscut	Shaft sinking	Station cutting	Total
At Sept. 1, 1920..........	464.0	595.0	6,074.0	2,993.0	816	109	11,051.0
For fiscal year...........	48.0	237.5	842.5	664.8	....	....	1,792.8
At Sept. 1, 1921..........	512.0	832.5	6,916.5	3,657.8	816	109	12,843.8

At August 31, 1921, ore reserves were estimated to be as follows:

	Tons	Av. Grade	Gross Value
Blocked-out ore	18,100	$11 04	$199,800 00
Broken ore	24,500	8 92	218,500 00
Total fully developed	42,600	$ 9 84	$418,300 00
Partly developed	56,290	$ 8 69	$488,840 00
Total ore reserves	98,890	$ 9 17	$907,140 00

In July, 1921, work was commenced to bring the treatment capacity of the mill up to the estimated capacity of the mine and surface equipment with only slight expenditures on mill, sleeping camp and electric power equipment. This work when completed should appreciably increase the profit to be derived from the known resources of the mine, and ultimately enable the profitable mining and treatment of blocks of ground in the mine that would otherwise have to be abandoned as unprofitable.

A supplementary report of the general superintendent for the last four months of the calendar year shows that the net profit per month from September 1 has been upwards of $10,000; also that the development on the sixth level has been so satisfactory that the treatment of 2,900 tons of ore during the month of December gave a gross return of about $46,000, which should yield about $25,000 net profit. Not only has some very satisfactory ore been encountered, but the work has developed some high-grade ore shoots, especially towards the eastern end of No. 3 vein at the 600-foot level. It is planned to continue the winze to the 980-foot level before starting stopes on the sixth level.

A re-organization of the company was effected at a general meeting of the shareholders held at Toronto on December, 7, 1921. The company as re-organized has a capital stock of 4,000,000 shares of $1.00 par value, all of which will be issued except 130,000 shares, which will remain in the treasury. In accordance with this plan the sale of 1,720,000 shares of the new issue of stock will leave outstanding in the hands of the bondholders only $342,000 of the new bond issue.

Tough-Oakes.—Tough-Oakes Gold Mines, Limited, resumed operations on April 15 with the de-watering of the mine. Development work began on May 22 with a force of 30 men which was later increased to 60.

During the year a total of 1,320 feet of development work was accomplished. This consisted of 899 feet of drifts, 404 feet of crosscuts and a 17-foot raise. The crosscutting was undertaken to prove the direction and extent of faulting that had taken place west of the main diabase fault and the upthrow caused by the vertical fault which cut off No. 2 vein immediately below the 400-foot level. The vertical fault has thrown the continuation of No. 2 vein into the adjoining Burnside property, now a part of the company's holdings, and the horizontal throw caused by the diabase fault is also southward into this property. Drifting at the 400-foot level on No. 3 vein showed a narrow but well defined vein carrying a little gold, and drifting on No. 11 vein for a distance of 263 feet developed ore of average grade with a width of 42 inches.

During the winter reconstruction of the surface plant was undertaken preparatory to resuming milling. Under the new scheme all ore will be handled from No. 3 shaft on the Burnside property which is being continued from the 400 to the 550-foot level.

Kirkland Lake Proprietary, (1919), Limited.—This company was formed in October, 1919, and is a re-organization of the Kirkland Lake Proprietary. The company holds a controlling interest in Aladdin Cobalt Company, Limited, and Tough-Oakes Gold Mines, Limited, and has absorbed Burnside Gold Mines, Limited. The registered office of the company is Finsbury Pavement House, London, Eng. The following are the directors: Capt. C. R. C. Jorgensen; Gen. Sir Bindin Blood, G. C. B.; Hon. K. H. Simpson, H. G. Latilla, A. Burt, H. J. Guntrip, secretary. S. C. Thompson, 43 Exchange Place, New York, is consulting engineer and W. R. Thomas, Kirkland Lake, manager. The capital of the company is one million shares of one pound each; 779,403 shares have been issued fully paid.

Wright-Hargreaves.—Wright-Hargreaves Mines, Limited, has an authorized capital of $2,750,000, in shares of $1.00 par value. The board of directors is as follows: Oliver Cavana, Jr., president; Edwin Lang Miller, vice-president and secretary; Gerard F. Miller, treasurer; Albert Wende, general manager; Ralph Hochstetter, Charles G. Duffy, Oliver G. Donaldson and Harcourt Ferguson.

Following is an abstract taken from the first annual report of the company, covering the year ending December 31, 1921:

> The mill was started on May 1, and during the ensuing eight months treated 36,081 tons of ore; the recovery was $468,665.64 in gold bullion or an average of $13.00 per ton. Since the mill was started it has run ninety-two per cent. of the possible running time and treated an average of 175 tons of ore per day.
>
> Most of the year's work was done on No. 2 vein, and since August 1 nothing has been done on No. 1 vein. The total amount of crosscutting and drifting up to the end of the year was 2,908 feet. Following are details regarding the stopes:

Stope.	Length in feet.	Broken ore in tons.
400 east	470	7,900
400 west	260	6,360
300 east	220	8,000
200 east	240	1,840
200 west	100	360

> On May 1, when the mill was started, the broken ore on hand amounted to 2,000 tons; on December 1, 25,085 tons.

Additions to plant included a 650-cubic foot air compressor, two air receivers and an electric signal system; also equipment to use exhaust steam for heating, and to condense the remainder so as to return all the water to the boiler.

An average of 103 men was employed.

Matachewan

Thesaurus.—The Thesaurus Gold Mines, Limited, has a capital of $1,000,000 in shares of $1.00 par value. The board of directors is as follows: W. R. Smythe, president; W. J. Shields, secretary-treasurer; J. C. Nelson, managing director; M. J. Conkey and W. L. Forest.

The company owns 271 acres at the head of Matachewan lake on the north side of the township of Baden.

The property was operated with a force of fifteen men from May 10th to Nov. 1st. After building a camp, a boiler and hoist house, and a blacksmith shop, 60 feet of sinking and 22 feet of crosscutting was done; power being supplied by a small steam plant.

West Shiningtree

Burke.—In October the Hollinger Consolidated Gold Mines, Limited, took an option on the Burke-Cochrane-Landagne group of claims (T.R.S. 3767, T.R.S. 3768, and others) west of Granite lake in Fawcett township. The company sank three or four shallow diamond drill holes and discontinued work in January, 1922. It is understood that the option has not been exercised.

Hologden.—Hologden Mines, Limited, was incorporated December 10, 1921, with a capital of $1,000,000 divided into shares of $1.00 par value. The head office of the company is at North Bay, Ont. The directors are: Hart Martin, president; Charles S. McGaughey, secretary-treasurer; Savario De Rosa; Angelo Chirico; Italio Giaya; all of the directors live in North Bay.

The following unpatented claims in the West Shining Tree area have been transferred to the company: T.R.S. 4043, T.R.S. 4228, T.R.S. 4229, T.R.S. 4666, T.R.S. 4912, T.R.S. 4913, and T.R.S. 4914; these claims are south of MacDonald lake in Asquith township.

About the middle of March, 1922, six men in charge of Savario De Rosa began doing assessment work and, when inspection was made March 23, they were sinking a pit near the camp on T.R.S. 4043; this pit was then 14 feet deep.

Miller-Adair.—The Miller-Adair claims, T.R.S. 4008, T.R.S. 3698, T.R.S. 4121, and T.R.S. 3541, aggregating 152 acres, are now owned by Miller-Adair Mines, Limited.

This company was incorporated June 3, 1919, but as yet has not done any work. The capital stock consists of 2,000,000 shares having a par value of $1.00 each; 1,000,000 shares have been issued to John Adair, Archie S. Burton, Charles A. Gentles, and Charles Millar, the vendors of the claims. The directors are: Charles Millar, president; Charles A. Gentles, vice-president; George R. Sproat, secretary-treasurer; Andrew W. Hunter, Charles H. Kemp; all of Toronto.

Wasapika.—The Wasapika mine in the West Shining Tree area, owned by Wasapika Consolidated Mines, Limited, was idle in 1921. George R. Rogers is president; James E. Day, vice-president; and Reginald E. Hore, secretary; all these officers reside in Toronto.

On November 24, 1921, a new company, Ribble Mines, Limited, was incorporated with a capital of $2,000,000. This company has acquired control of the Wasapika Consolidated Mines, Limited, and will operate the Wasapika mine, commencing in the spring of 1922. The head office of the new company is at 304 C.P.R. Building, Toronto, and the directors are: George R. Rogers, president and general manager, Toronto; Reginald E. Hore, vice-president, Toronto; James E. Day, Toronto; L. J. Lahay, Toronto; J. C. Mahon, Cobalt.

White Rock.—White Rock Mining Company, Limited, mentioned in the last report of this Department, resumed work in the spring of 1921. This company is prospecting the Saville vein, which strikes in a northwesterly direction and dips to the southwest at about 65 degrees.

On March 22, 1922, the date of last inspection, the shaft was 175 feet deep and levels had been opened at 65 and 170 feet. This shaft is vertical, divided into two compartments, and measures 6 feet 4 inches by 11 feet outside the timbers. It was started at the top of a 65-degree incline that had been sunk 45 feet on the vein, and as much of this incline as was practicable was used to form the upper portion of the vertical shaft. On the 65-foot level the work done consisted of a crosscut, 21 feet long, from the shaft to the vein, 165 feet of drifting to the northwest and 100 feet to the southeast. On the 170-foot level there was an 86-foot crosscut to the vein, 35 feet of additional crosscutting, 140 feet of drifting to the northwest and 120 feet to the southeast.

The machinery includes two locomotive-type boilers, a 50-h.p. and a 35-h.p., an 85-h.p. Peerless engine driving a 300-cubic foot Gardner compressor, a 6-inch by 8-inch Jenckes hoisting engine, a 9-inch by 14-inch Mitchell jaw crusher, a 15-h.p. Jewel engine to drive the crusher, a 2-stamp Tremaine mill, a circular saw, and an O. and S. engine to drive the saw.

A small quantity of ore was stoped above the first level, stamped in the Tremaine mill and amalgamated.

The directors, all of whom live in Sudbury, are: William McVittie, president; W. Arthur Evans, vice-president; Charles Jessup, Maurice Cohen, Charles McCrea, M.P.P. A. J. Manley, Sudbury, is secretary, and William Stevenson, Shining Tree, Ont., superintendent.

Howry Creek

The three gold prospects mentioned below are in the Howry Creek area and were described in the last Annual Report:

Bousquet.—Bousquet Gold Mines, Limited, continued to prospect its property near Howry Creek until October, when all work was stopped. Besides doing considerable trenching, the company sank a 2-compartment shaft to a depth of 110 feet, and did 280 feet of lateral work on the 110-foot level.

Wm. B. McPherson, Imperial Bank Building, 171 Yonge Street, Toronto, is secretary of the company.

Howry Creek.—The Howry Creek Mining Corporation, Limited, stopped work on December 21, 1921. The underground work done up to that date was as follows:

An adit was driven a total distance of 428 feet; at the point where it was expected the vein would be cut, only a tight fracture in the quartzite was found.

About 110 feet east of the line of the adit a 5-foot by 7-foot shaft was started and sunk 50 feet. The vein in the lower part of this shaft is reported to be about 20 inches in width.

Near the east end of the outcrop a pit, 10 feet deep, was sunk.

A. K. Anderson of Ottawa was superintendent.

Majestic.—Majestic Gold Mines, Limited, did a little prospecting on one of its claims about half a mile west of West River station on the Algoma Eastern railway.

When the last inspection of this property was made (February 16, 1922) No. 1 shaft was 33 feet deep and a pit, being sunk about 160 feet to the northwest of the shaft, was ten feet deep. Small camps and a boiler house have been built. The latter building contains a Nagle locomotive-type boiler, a small Canadian Rand compressor and an Anaconda-type hoist.

M. A. Attalah, 213 Carlton Street, Toronto, is president of the company, and Peter Greco is mine superintendent.

Silver

Cobalt

Aladdin.—The Aladdin Cobalt Company, Limited, operated during most of the past year on the southeast portion of the Chambers-Ferland property; the work was done through the Right-of-Way shaft which was leased. Good results were obtained in the early part of the year and several new veins were encountered close to the Nipissing boundary. Unfortunately, on getting to the Keewatin the results were disappointing and the work was discontinued in November. About 20 men were employed under superintendent John Matheson.

During the period from January to November the development work amounted to 1082 feet divided as follows: drifts 465 feet; crosscuts 386 feet; raises 170 feet; winzes 61 feet. The production was 38,031 ounces of silver which yielded a return of $22,774.82.

As Kirkland Lake Proprietary, 1919, Limited, was re-opening the Tough-Oakes gold mine it was decided to suspend work at the Aladdin. Mr. W. H. Goodchild made a geological examination of the Aladdin in November and reported that the company's property lying between the Nipissing and LaRose mine may still be ranked as first-class prospecting ground, and it is expected that operations may be resumed in the near future.

Bailey.—The Bailey Silver Mines, Limited, with a capitalization of $1,250,000, owns and operates the Bailey mine at Giroux Lake and the mill formerly owned by Northern Customs Concentrators, Limited, at North Cobalt. In December a lease was taken on the Silver Cliff mine.

The officers of the company are: A. J. Young, president; W. R. Sweeney, secretary-treasurer; G. C. Bateman, consulting engineer, and R. E. Dye, mill superintendent.

During the year ending December 31, 1921, the Bailey mine shipped 11,600 tons of ore from which was recovered 81,749 ounces of silver. This ore came from 5A and 5B veins above the fifth level, and also from the extension of the Big Pete vein workings above the fourth level.

The mill treated a total of 49,619 tons and received a gross revenue of $141,925.00, from which was realized an operating profit of $37,813.00. This ore came from the following properties:

Bailey mine	11,600.21	tons
Silver Cliff mine	247.79	"
La Rose mines	36,364.91	"
Aladdin Cobalt Co.	607.01	"
Silver Leaf dump	180.84	"
Ophir dump	53.95	"
Silver Queen mine	448.76	"
Hermo Mining Co. (Reliance)	115.19	"
Total	49,618.66	tons

Cobalt A-53.—The Cobalt A-53 property in Gillies Limit was operated by J. J. Byrne with a force of five to six men during the last two months of the year. About 100 feet of drifting was done on the 60-foot level, and during the winter months a 40-foot winze was sunk from this level at a point southeast of the shaft.

The property is owned by the Cobalt A-53 Silver Mining Company, Limited, the officers of which are: R. J. Hart, Toronto, president; Edwin Stansbury, first vice-president; A. W. Hennessey, second vice-president; H. S. Honsberger, 119 Bay St., Toronto, secretary-treasurer; K. Nelson, Benjamin Trumin and W. H. Matthews.

Coniagas.—The Coniagas Mines, Limited, has a capitalization of $4,000,000, divided into shares of a par value of $5.00. The company owns the Coniagas mine at Cobalt and the Coniagas Reduction Company, Limited, whose smelter is at Thorold.

The board of directors consists of R. W. Leonard, president, St. Catharines; Alex. Longwell, vice-president, Toronto; F. D. Reid, general manager, Cobalt; R. P. Rogers, Woodstock; A. L. Bishop, St. Catharines; H. H. Collier, St. Catharines; R. L. Peek, Deschênes, Quebec. J. J. Mackan of St. Catharines is secretary-treasurer.

During the year the Coniagas Reduction Company, Limited, shipped 1,486,857 ounces of fine silver and treated 1,413 tons of ore (dry weight). The average number of men employed was 94.

The following information regarding the operation of the Coniagas mine is taken from the annual report of the company for the year ending October 31, 1921:

> Development work at the mine consisted of exploring further small blocks of undeveloped ground, and of developing stringers and small veins discovered in stoping. This work disclosed a large tonnage of low-grade milling ore. The underground electric haulage system was completed. The work performed during the year included 595 feet of drifting, 112 feet of crosscutting, 23 feet of winze-sinking and the stoping of 110,840 tons of ore. Shipments of high grade ore amounted to 25.46 tons dry weight, averaging 4,406.63 ounces of silver per ton. The concentrating mill and flotation plant

were operated continuously during the year, the ore milled being 113,279 tons or an average of five and a half tons per stamp per 24 hours. Mill heads averaged 11.3 ounces per ton. Shipments of high grade concentrates amounted to 402.47 tons, averaging 1950.26 ounces silver per ton.

The flotation plant, which treats tailing from the concentrating mill and reground sand from the tailing pile, made an extraction of 68.29 per cent., leaving a tailing of 1.62 ounces of silver per ton. Flotation concentrate amounted to 536.88 tons, averaging 655.24 ounces silver per ton.

Old sand tailing treated during the year amounted to 19,125 tons, and an average of two ounces per ton was recovered. Cyanidation of old slime tailing was carried on from May 17 to October 31, the yield being 50,000 ounces of silver from 14,931.6 tons treated.

During the year 1,301,514.91 ounces of silver were shipped, and $800,000 in dividends were paid.

Dickson Creek.—The Dickson Creek (Cobalt) Silver Mines, Limited, continued development on its property in the northeast quarter of the north half of lot nine, concession V, Bucke Township, from June 21 to the end of 1921. H. Hollands-Hurst, Haileybury, is superintendent, and seven men are employed.

The shaft was continued from 250 to 325 feet, and an 18-foot station cut at the 300-foot level; from this station crosscuts were driven 104 feet northwest and 109 feet southeast.

The head office of the company is at 33 Old Broad Street, London, E.C. 2. The directors are: Thos. Dempster, president, Perth, Scotland; J. A. Crumble; J. J. Knight; A. E. T. Price; and Phillip Hurst.

Kerr Lake.—Kerr Lake Mines, Limited, has a capitalization of $2,400,000 in shares of $4.00 par value. The head office is at 61 Broadway, New York. The officers of the company are: Adolph Lewisohn, president; Sam A. Lewisohn, vice-president; E. A. Westlake, secretary-treasurer; H. A. Kee, Cobalt, manager. An average of 90 men was employed.

During the fiscal year ending August 31, 1921, the total advance by drifting, crosscutting, raising and sinking amounted to 3341.25 lineal feet. Most of the exploration during the past year was done in the northerly and southerly extensions of the No. 3 diabase vein structure on different levels. This work exposed some high grade ore as well as a little milling ore, though none of the discoveries in the Kerr Lake area proved of great importance.

During the early work on No. 3 vein high-grade ore shoots were procured in known horizons, the lower portions of which were about 125 feet above the lower Keewatin-diabase contact; recently pockets of high grade ore have been found close to this contact in both formations. It is planned to continue development at favourable levels along the contact in Kerr Lake and Hargrave areas.

The development and stoping figures for the year September 1, 1920, to August 31, 1921, are as below:

Drifting	1,975.50	Lin. feet
Crosscutting	889.50	Lin. feet
Raising	396.75	Lin. feet
Sinking	79.50	Lin. feet
Total Development	3,341.25	Lin. feet
Total Stoping and Sideslashing	2,939.00	Sq. feet
Total development to August 31st, 1921:		
Previous to September 1st, 1920	59,890.55	feet
Total for year	3,341.25	feet
Grand Total	63,231.80	feet

Development work was continued till January 31, 1922, and an additional 1,104 feet driven as follows: drifts 894 feet, crosscuts 60 feet, raises 150 feet.

The recovery from the year's operations was 194,352 ounces of silver and 17.096 pounds of cobalt. Ore milled amounted to 11,235 tons.

The Hargrave property, consisting of 80 acres, was acquired in March for a purchase price of $16,500. Since that time a small ore shoot has yielded about 36,000 ounces of silver from high-grade ore, and a further production is anticipated.

Four dividends of $75,000 each were paid during the year which brings the total distribution to date to $8,610,000, in addition to a capital distribution of $600.000 in 1919, or $1.00 per share.

The company began operations on the Goldale (gold) property in Porcupine in April, 1922.

La Rose.—La Rose Mines, Limited, with a capital of $1,500,000, in $1.00 shares, operated the La Rose, Violet, Princess and University mines at Cobalt. The officers of the company are: D. Lorne McGibbon, president; Shirley Ogilvie, vice-president; Stephen J. Le Huray, secretary-treasurer; G. C. Bateman, general manager. The head office of the company is at 260 St. James St., Montreal.

During the year the company produced from all sources 637,042 ounces of silver having a net value of $390.957.51, as compared with 410,445 ounces in 1920, having a value of $313,995.74. The profit on production was $126,088.83. The average selling price was 63.54 cents per ounce, and the cost of production 46 cents per ounce, as compared with 83.41 cents and 73.27 cents in 1920. The current net surplus on Dec. 31, 1921, amounted to $555,910.00. This is the most favourable showing for any year since 1916.

The 36.365 tons of ore shipped to the concentrator had an average content of 15.7 ounces per ton and yielded 659 dry tons of concentrates averaging 759 ounces per ton, or a total of 500,114.53 ounces for which the smelter return was $298,677.63. The cost of concentration was $102,395.78, or $2.81 per ton milled, and the extraction 87.6 per cent. on a ratio of concentration 55 to 1.

The following tables give a summary of the work done on the several properties and the output of each during the year:

Work done:—

	Shafts ft.	Drifts ft.	Crosscuts ft.	Raises ft.	Stations cu. yds.	Stopes cu.yds.
La Rose	4.5	7.5				476
Princess	45.5	475.	548.5	54.	122	2,122
University	22.5	1,486.5	1,904.5	348.		6,031
Violet	65.0	224.0	57.5	9.5		344
Total	137.5	2,193.0	2,510.5	411.5	122	8,973

The production by properties was as follows:—

	Tons	Value
La Rose	11.00	$ 18,381 82
Princess	16.81	7,237 32
Violet	1.70	1,446 48
University	29.13	109,861 92
Concentrate	659.26	500,114 53
Totals	717.90	637,042 07

The *Violet* mine remained flooded below the 330-foot level until August when it was pumped out and a crosscut started from the bottom of the winze on the 530-foot level. No. 4 vein was encountered 35 feet south of the winze where it showed a width of from five to six feet of milling ore. It was drifted on for a distance of 225 feet and in the course of drifting and preparations for stoping there was removed a total of 1.599 tons containing 49,730 ounces of silver, or an average of 31.1 ounces per ton. In December work on the 530-foot level was stopped to permit sinking the winze to the 600-foot level. This depth has now been reached and a crosscut has been started to intersect the vein.

The *Princess* mine production came from the cleaning up of old stopes, from veins previously discovered, and from the extension of No. 1 vein below the third level which was developed by an incline. Practically all of the known ore has been mined, and the possibilities of new discoveries are limited. It was decided to sink from the lowest level to explore at greater depth a small area where the geology is favourable, and this work is now proceeding.

The *University* mine was operated continuously during the year, and contributed 70 per cent. of the total output of the combined properties. The profit realized was almost sufficient to pay off the indebtedness to the La Rose company. The main stope opened in 1920 was exhausted although it still contains broken ore, but a new ore body lying to the north of this stope was discovered close to the contact of the diabase with the slates. In places it has a width of 20 feet of milling ore together with small stringers of high grade. Contrary to the general experience of the Cobalt camp practically no ore has been found in the conglomerate, the silver here being almost entirely confined to the overlying slates, of which there is still a considerable area to be prospected.

Mining Corporation.—The Mining Corporation of Canada, Limited, has a capital of 1.660,050 shares of a par value of $5.00. The directors and officers are: J. P. Watson, president; W. R. P. Parker, first vice-president; G. M. Clark, second vice-president; E. H. Rose, J. G. Watson, Thos. Plunkett; Capt. C. E. Trafford, directors: Scott Turner, consulting engineer: M. F. Fairlie, mine manager; G. C. Ames, secretary. The head office is 1512-1520 Bank of Hamilton Building, Toronto.

The following information is taken from the eighth annual report of the corporation:

> The Cobalt Reduction Company treated 72,664 tons of ore in the concentrating plant and produced 548.44 tons of concentrate containing 928,845 ounces of silver. Of this ore 29,207 tons came from the Mining Corporation, 43,385 tons from the Buffalo, 50 tons from the Foster, and 22 tons are classed as "sundry." The slime from the concentrating plant, 35,986 tons, was treated in the cyanide plant and 301,219.70 ounces of silver recovered. The high-grade plant treated all the concentrate produced in the low-grade mill, the high-grade ore from the mine and 475.80 tons of purchased high-grade ore and concentrate. The refinery produced 1,966,946.84 ounces of refined bullion. The flotation plant was not operated during the year.
>
> Ore reserves are estimated at 102,300 tons containing 1,935,750 ounces of silver, as against 103,603 tons containing 2,181,000 ounces in 1920.
>
> Mining and milling were discontinued from March 7 to May 25 while changes were being made to increase the milling capacity.
>
> Exploration at the Foster failed to develop any new ore and the property was closed down in October.
>
> An option was taken on the Frontier mine in South Lorrain and development will be carried out in 1922.

Nipissing.—The Nipissing Mines Company, Limited, has an authorized and issued capital of 1,200,000 shares of a par value of $5.00. The officers of the company are:- E. P. Earle, president; Alexander Fasken, secretary; P. C. Pfeiffer, treasurer. The directors are: E. P. Earle, Richard T. Greene, August Heckscher, R. B. Watson of New York, and W. H. Brouse, John H. Black and David Fasken of Toronto. The head and corporate office is in the Excelsior Life Building, Toronto, and the New York office is at 165 Broadway.

The operating company is the Nipissing Mining Company, Limited, with an issued capital of $250,000 in shares of $100.00 par value. The officers are: David Fasken, president; E. P. Earle, vice-president; Alexander Fasken, secretary; P. C. Pfeiffer, treasurer. The directors are: John H. Black and David Fasken of Toronto; E. P. Earle, Richard T. Greene and R. B. Watson of New York. The operating officers are: R. B. Watson. general manager; Hugh Park, manager; James J. Denny, mill manager. The head office is in the Excelsior Life Building, Toronto.

During 1921 production amounted to 3,156,775 ounces of silver having a gross value of $1,869,566.41, and a net value of $968,768.51. The total cost of producing this silver was 900,779.90, or 28.53 cents per ounce, or $11.16 per ton of ore treated. The operating cost represents 48.2 per cent, and the operating profit 51.8 per cent of the gross value. Up to the end of 1921 the company had shipped a total of 61,855,567.39 ounces of silver, for which the net value received was $40,076,751.78. Of this total $23,640,000 has been paid in dividends. During the year a total of $900,000 or 15 per cent. of the capital was returned in dividends. The surplus on hand is $3,851,242.94.

Shipments in 1921 were:

	Tons	Fine ounces silver	Net value
Silver bullion	108.32	3,155,538.84	$1,828,095 80
Silver ore	2.43	66.26	46 38
Total shipments	110.75	3,155,605.10	$1,828,142 18
Less custom bullion	4.76	138,844.68	82,731 11
Shipments of Nipissing product	105.99	3,016,760.42	$1,745,411 07

The following information is taken from the seventeenth annual report of the company:

The various products treated in the high-grade plant were:

	Tons	Assay ozs.	Contents ozs.
Nipissing concentrate	1,511	1,498	2,263,084
Custom ore	73	1,812	131,517
Bi-products	41	2,301	95,665
	1,625	1,532	2,490,266

Formerly the ore was ground in a tube mill with water and bleaching powder and then sent to the cyanide treatment. The use of bleaching powder has been discontinued; the ground ore is now agitated in a 3 p.c. sulphuric acid solution to eliminate cyanicides, principally the oxidized compounds of nickel. After two water-washes the remaining acid is neutralized with lime and the usual cyanide treatment follows. This preliminary acid treatment results in a saving of from 25 to 30 lbs. sodium cyanide per ton of ore treated.

Residue produced amounted to 1,878 tons, carrying an average of 57 ounces silver and 6.8% cobalt. The cobalt market was very quiet; no residue shipments were made during the year.

The refinery treated precipitate from both mills and custom bullion containing 3,527,638 ounces.

Shipments of 3,155,539 fine ounces were made during the year.

The following shows the operations of the low-grade mill:—

	Tons	Assay	Ounces
Ore treated	80,720	41.58	3,356,318
Recovered in products			
Precipitate	41	23,953	976,584
Coarse concentrate	1,321	1,580	2,087,312
Fine concentrate	177	511	90,424
Total recovery			3,154,320

Average tailing, 2.48 ounces. Recovery, 93.98%.

Forty stamps ran 322 days, 18 hours, or 88.56% of possible running time, and crushed 250.1 tons per day, or 6.267 tons per stamp per day.

The above summary shows the results of the first full year's run since the closing of the picking plant for high grade ore. All the ore, high-grade and low-grade mixed, is now sent directly to the stamps. Notwithstanding an exceptionally difficult ore to treat compared with former years, the recovery was good and the treatment cost was lowered.

The following work was done underground in 1921:

Shaft No.	Drifting feet	Crosscutting feet	Raising feet	Sinking feet	Total feet	Stoping cu. yds.
63	1,564.5	1,252.0	353.5	37.0	3,207.0	8,166.0
64	26.5	....	310.0	....	336.5	906.3
73	630.5	1,581.5	596.0	....	2,808.0	6,855.3
Totals	2,221.5	2,833.5	1,259.5	37.0	6,351.5	15,927.6

The total underground advance during the year was somewhat less than in 1920, due partly to destruction by fire of the headframe at Shaft 73 in the month of April. The work done at Shafts 64 and 73 was consequently reduced. The fire did not affect operations at the mill, as extra tonnage was obtained from Shaft 63.

For some years past a large proportion of the ore produced has come from the north side of the lake within the town of Cobalt. Last year, however, more than half the underground development took place on the east side of the lake and the present ore reserves are about equally divided between the two sides.

Underground work was carried on in 128 faces exclusive of stopes, of which there were 23.

As usual, a number of new veins were found, but none was of much importance with the exception of Vein 251 in the Shaft 63 workings.

Good results were also obtained in blocking out new ore in Vein 64.

Shaft 63. There was a considerable increase shown in the tonnage extracted through this shaft due to the development of several small veins recently found and to work on the Little Silver vein, which was the first silver vein found on the Nipissing property; it still holds a reserve of 227,000.

The most satisfactory result from exploration was the discovery of Vein 251 by a crosscut from the second level. The drift at that level disclosed an ore shoot 70 feet in length with an average of 3 inches of ore assaying 3,500 ounces. A winze put down at the end of the year shows that the vein maintains its width and assay to a depth of 55 feet where the Keewatin was encountered. Drifts near the contact are now being driven from the bottom of the winze, with excellent results to date.

In this piece of ground lying west of Cart lake and known as Little Silver hill, a number of good veins have been developed and it is still being extensively explored.

Shaft 19. This old shaft was reopened during the year to extract the ore remaining No. 6 open cut which had not been worked since the early days of the property. It will produce some thousands of tons of average ore.

Shaft 64. Stoping and development on Vein 64 were considerably increased, due to the completion of haulage facilities to the main hoisting shaft on Vein 73. Substantial increases in ore reserves, both high grade and mill rock, resulted from this work. The vein occurs in a large fault which is only mineralized in spots. The average assay of the high grade ore is about 1,000 ounces, but parts of the vein will assay much higher over widths of from one to two feet. This vein will be one of the main producers during the coming year.

Although considerable exploration has been done to the north of Vein 64, the ground does not appear promising, and nothing of interest has developed.

Shaft 73. The older veins worked through this shaft continued to produce a large part of the ore milled, but such new veins as were found during the year proved of minor importance. Vein 490 was drawn on heavily, but still shows a fair amount of ore in reserve with possibilities of further increases.

Shaft 128. A fairly large area of comparatively thin conglomerate will be explored from this shaft. A few veins, small and low grade, occur here and there at the surface. The old level at 125 feet proved to be too deep to explore all the area, so a new level has been started at 75 feet.

O'Brien.—The O'Brien mine produced 1,506,384 ounces of silver in 1921; this is the largest amount since 1909, and makes the O'Brien now the second largest producer in Cobalt.

The underground work done during the year is summarized thus: 795 feet of drifting, 602 feet of crosscutting, 395 feet of raising, 19 feet of sinking, and the stoping of 56,119 tons of ore.

In the mill 58,924 tons of ore were treated; this makes the total ore milled from this mine to the end of 1921 546,789 tons. Of the 1,506,384 ounces of silver recovered during the year, thirty per cent was contained in bullion and seventy per cent. in concentrate. Several new tanks were added to the cyanide plant.

The total number of men employed during the year averaged 165; 100 of these were underground workmen, 33 were in the mill, and 32 at other surface work.

The mine is owned by M. J. O'Brien, Limited, of which the officers are: president, M. J. O'Brien, Renfrew; vice-president, J. A. O'Brien, Ottawa; mine manager, J. G. Dickenson, Cobalt.

Oxford Cobalt.—Oxford Cobalt Silver Mines, Limited, has an authorized capital of $1,000,000. The officers of the company are: A. H. Wilson, president; J. R. Shaw, vice-president; E. A. Rea, treasurer; G. W. Mahon, secretary; J. W. Russell, general manager.

This company owns mining claims A-100 and C-1000 in the Gillies Limit. During the latter half of the year on claim A-100 an 80-foot shaft was sunk and a station cut at the 75-foot level. On mining claim C-1000 170 feet of drifting was done on the 150-foot level of No. 3 shaft and 20 feet from No. 2 shaft. Eight men were employed.

Reliance.—The Reliance Silver claim near Cobalt was worked under lease by the Hermo Mining Company from August 1, 1921, to March 1, 1922.

W. H. Emens of Cobalt was in charge and had five men employed.

The following development work was done; the sinking of a winze from No. 1 shaft workings to 47 feet below the 50-foot level; the sinking of No. 2 shaft to a depth of 45 feet and 144 feet of drifting.

One hundred and fifteen tons of ore were shipped to the Bailey mill, which yielded 1.2 tons of concentrate assaying 553.6 ounces of silver per ton.

Silver Cliff.—The Silver Cliff mine was operated under lease by the Bailey Silver Mines, Limited, during the last two months of the year and 247.79 tons of milling ore was shipped to the company's concentrator for treatment.

Silver Queen.—Silver Queen mine was operated under lease by W. J. Post during the latter part of the year with a force of two men. A crosscut was driven 90 feet south on the 90-foot level during December and January.

During 1921 milling ore amounting to 448.76 tons was shipped to the Bailey mill.

From May to July, 1922, shipments were made to the Cobalt Reduction Company of 2.88 tons containing 3,660.27 ounces of silver, and metallics containing 493.95 ounces.

Victory.—Victory Silver Mines, Limited, was incorporated May 20, 1920, with a capitalization of $2,000,000, divided into shares of $1.00 each. The officers and directors, all of whom live in St. Catharines, Ont., are: president, A. Patterson; vice-president, W. K. Masterton; secretary-treasurer, F. E. Hetherington; directors, John Morton and A. G. Christopher. The head office is at 10 Queen Street, St. Catharines.

The company gave 750,000 shares of stock for the assets of the Victory Silver Mining Company, Limited; the mining claim involved was the "Hyland," a ten-acre claim, north of the Ophir mine and in the southeast part of lot 2, concession III, township of Coleman.

The shaft on this property was sunk by former owners to a depth of 200 feet. In 1921 the new company did 150 feet of drifting and 175 feet of crosscutting on the 185-foot level, in addition to sinking the shaft to a depth of 285 feet. Eleven men were employed under manager J. A. McVichie.

South Lorrain

Haileybury Frontier.—The Haileybury Frontier Mine in South Lorrain was operated during the year by H. F. Strong of Haileybury for the Dominion Mines and Quarries, Limited, with a force of about 30 men. James G. Harkness was superintendent.

During the first five months of the year about 1,000 feet of drifting was done on the 150-foot level. During the next three months the shaft was deepened to 150 feet, and a station cut at the 300-foot level. Some 400 feet of development work was done on the 300-foot level before November 13, when the Mining Corporation of Canada took a working option on the property and began working it as the Lorrain Operating Company. About 300 feet of additional development work was done by this company on the 300-foot level. A diamond-drill hole 478 feet in depth was also put down to the diabase contact, which was encountered at 450 feet.

In December a shipment of 16.85 tons of high-grade ore containing 47,374.43 ounces of silver was made to the Dominion Reduction Company at Cobalt.

Keeley.—The Keeley Silver Mines, Limited, operating the Keeley mine in South Lorrain, has a paid up capital of £133,000 sterling. The head office of the company is at 65 Broad St. Ave., London, E.C. The directors are:—E. Hooper, chairman, A. H. Collier, E. Turk and J. C. Williamson. Dr. J. Mackintosh Bell is general manager.

An average of 65 men was employed.

The property was closed from December 1, 1920, to April 6, 1921, and milling began in June.

Mining operations have been limited to the No. 3 shaft on the following levels:

	No. 3	No. 4	No. 5	No. 6	Total in feet
Drifts	63	31	826	506	1426
Crosscuts	21	..	57	79	157
Side-slashing	9	47	48	40	144
Raises	..	..	74	38	112
Winzes	..	..	75	..	75

Mill at Keeley Silver Mine, 1921.

The total production was 313,229 ounces of silver and 59,530 pounds of cobalt, divided as follows: 181,313 ounces of silver and 18,644 pounds of cobalt in high-grade ore, and 131,916 ounces of silver and 40,886 pounds of cobalt in mill concentrates.

The mill treated 9,204 tons, and produced 266.5 tons of concentrates. The heads averaged 17.8 ounces and the tails 3.5 ounces, giving a recovery of 80.5 per cent.

New equipment includes a 52-horse power electric hoist at No. 3 shaft, and a 10-horse power triplex electric pump on the sixth level.

A number of new veins were discovered during the year. The more important were No. 15, which branches easterly from No. 6 at the fifth level, and

No. 16, branching westerly from the Woods' vein at the sixth level. Development along the No. 16 has been carried on at both the fifth and the sixth levels, and along the No. 15 only at the fifth level. Development on the Woods' vein at the sixth level along a much shattered overthrust fault showed continuous ore from a point 25 feet south of the main crosscut to a point 220 feet north, or for a total distance of 245 feet.

Elk Lake and Gowganda

Alpine.—Alpine Silver Mines, Limited, has a capitalization of $2,000,000 in $1.00 shares. Charles O. Taylor, Chicago, Ill., is president, and Thos. B. Tough, Huntsville, Ont., vice-president. The company owns mining claims in the Township of Van Hise near Spawning lake.

During the summer and autumn, camps, a magazine and an office were built, a 45-horse power locomotive-type boiler and a three-drill air compressor were installed, and an adit was advanced 120 feet. There were 10 men employed under E. J. Thompson.

Collins Mine.—In July F. Howard Collins resumed work on his property at Leroy lake with a force of seven men. Most of the work was done on the 288-foot level near the Keewatin-diabase contact. This consisted of drifting 25 feet north and 36 feet south and crosscutting 83 feet to the east. A small amount of drifting was also done in No. 2 shaft at a depth of 48 feet.

Miller Lake O'Brien.—The Miller Lake O'Brien mine near Gowganda is owned and operated by M. J. O'Brien, Limited. J. G. Dickenson, Cobalt, is manager and H. G. Kennedy, Gowganda, resident superintendent.

Development work in 1921 consisted of 1,424 feet of drifting and crosscutting and 54 feet of raising. There were 9,353 tons of ore stoped and 15,878 tons of ore hoisted. The mill treated 8,425 tons of ore and the production was 245,624 ounces of silver. An average of 68 men was employed.

A shortage of waterpower toward the end of the year interfered with the work, and necessitated closing the mill from November, 1921, to May, 1922. To provide greater water storage capacity, a dam was built on the east branch of the Montreal river.

Early in 1922 the Miller Lake O'Brien mine bought the property of The Bonsall Mines, Limited, consisting of eight claims adjoining the Miller Lake O'Brien on the west.

Northcliff.—On October 1, Northcliff Mines, Limited, resumed work on its property on the northwest arm of Gowganda lake. On November 1 the adit measured 260 feet and 40 feet of drifting had been done 125 feet from the portal. Seven men were employed under Norman E. Dye until the mine was shut down for the winter.

Ontario Solid Silver Mines.—Col. D. Shepp let a contract in December, 1921, to Roy Sullivan and three associates to sink a 50-foot shaft on the company's property in Cane township, adjoining that of the Cane Silver Mines. This was completed February 18 and work was resumed on March 11, 1922, with the intention of sinking to 100 feet.

Sanderson.—The Sanderson claims, H.R. 404-411 and L.O. 314-15 in Lawson township near Wigwam were worked under option by Stewart Troop of Montreal, from April to July 20. A shaft was sunk on claim H.R. 406 half a mile north of the Bishop mine to a depth of 83 feet, and a boiler house and smithy built. From six to eight men were employed.

Castle.—The Trethewey Silver Cobalt Mining Co., Limited, operated the Castle property with a force of from 30 to 55 men until June 25, when a fire destroyed the power house. The shaft was sunk from 70 feet to 260 feet and 300 feet of drifting and crosscutting was done at the 160-foot level, Murray D. Kennedy is manager.

At the annual meeting in January, 1922, a new company, the Castle-Trethewey Mines, Limited, was formed with a authorized capital of $2,000,000 in shares of $1.00 each. Of this capital stock 400,000 shares were exchanged for the stock of the Castle Mining Company, Limited, and 1,600,000 shares were offered to shareholders at 10 cents per share to provide funds for future work.

IV.—SOUTHERN AND EASTERN ONTARIO

Calcite and Dolomite

Baptiste Lake Dolomite Deposit.—In 1916 Alex. Watson of 76 Coleridge Avenue, Toronto, bought a piece of land on the southwest shore of Baptiste lake, with a view to prospecting a deposit of dolomite which outcrops about 30 chains west of Baptiste station on the Irondale, Bancroft and Ottawa branch of the Canadian National Railways. The deposit lies beside the railway, and outcrops on the side of a hill some 350 feet high. In 1921 Mr. Watson transferred his holdings, which are in lots 23, 24, and 25, concessions IV and V, township of Herschel and contain 124 acres, to the Ontario Dolomite Manufacturing Company, Limited. This company hopes to market the dolomite for the manufacture of paints.

The property was visited on September 21, 1921, when five men were working under Mr. Watson's supervision. As near as could be judged at that time, the dolomite occurs in the form of a bed having a dip of from 20 to 40 degrees to the south and a strike of about 135 degrees. As the property was visited late in the day and during a rainstorm, no measurements were taken, but the portion of the deposit exposed at the point where most of the stripping has been done showed six feet of rather impure dolomite at the base, the impurities consisting of serpentine and mica in streaks; above this there was from 15 to 25 feet of dolomite of apparently good quality exposed, and the thickness may be greater, as the upper contact was not examined. The dolomite is underlain by a gneissoid rock.

Work was carried on from August to October, stripping, test-pitting, and drilling with a shot-drill.

The officers of the company are:—president, Robert M. Smith, Toronto; vice-president, F. W. Burnip, Toronto; secretary-treasurer, Harold A. Burnip, Toronto. The office of the company is in the Standard Stock Exchange Building, 56 King Street West, Toronto.

Caldwell Calcite Deposit.—A large deposit of calcite, white to cream in colour, has been discovered on the farm of James Crain in the west half of lot 4 in the seventh concession of the township of Palmerston, county of Frontenac. Thomas B. Caldwell of Perth, Ont., bought the mineral rights, and in October and November, 1921, quarried about 200 tons for experimental purposes. This work was done at the southeast end of the lot at a point where a width of 60 feet of calcite, apparently free from impurities, is exposed; neither wall was uncovered at this excavation. The strike of the deposit is approximately east and west. Twelve hundred feet west of the opening mentioned above, at the edge of a beaver meadow, a face of pure calcite is exposed 35 feet high; the deposit is 60 feet wide at this point. The haul to Robertsville siding on the Kingston and Pembroke branch of the Canadian Pacific Railway is about two miles.

Corundum

Corundum, Limited.—The re-treatment mill at Craigmont was operated for four and three-quarter months in 1921, closing on June 14. During that time 11,256 tons of tailings were re-treated, producing 289 tons of corundum. An average of 30 men was employed. E. B. Clark of Craigmont is manager.

Feldspar

Eureka Flint and Spar Co., Limited.—The Company's property is in Portland township, concession XI, lot 16. It closed down its Emery feldspar property near Verona in April, 1921, and had not resumed work up to the end of the year. John Wilkes, 39 Logan Avenue, Trenton, N.J., is field manager for the company and Richard Wagar of Verona is superintendent of the Emery quarry.

Federal Feldspar, Limited.—The McGregor feldspar mine, in lot 25, concession III, Bedford township, near Tichborne and owned by this company, has not been worked since November, 1920. John O'Toole, 250 Slater Street, Ottawa, is vice-president and manager.

Feldspar Quarries, Limited.—This company owns the Brebner and Timmins feldspar quarries near Verona and the O'Holloran feldspar quarry near Perth, all of which have been mentioned in former Annual Reports. All three properties were closed in the spring of 1921, and have not been worked since.

The officers of the company are:—president and managing director, W. H. Despard, 48 Crescent Road, Toronto; treasurer, Donald A. Cameron, Toronto; secretary, Miss N. F. Martin, Toronto; manager, Gordon C. Edwards, Verona, Ont.

Feldspar, Limited.—This is the well-known Richardson feldspar mine on lot 1, concession II, Bedford township. Nothing was done at this property from December, 1918, until August, 1921, when men were engaged to sort the dump. This work was still in progress at the end of the year, and was employing from 10 to 14 men. J. Ralph Scott, R.R. No. 1, Hartington, Ont., is manager.

A new road is being built to lead due north from the mine to a junction with an old road a mile from Glendower station.

Gardner Feldspar Co.—This company worked a feldspar vein on the Babcock farm, Loughborough township, concession XI, lot 1, near Holleford, until February 12, 1921. In the autumn Joseph H. Mendels of Perth shipped some feldspar from the deposit.

International Feldspar Company, Limited.—The Hoppins feldspar mine, Bedford township, concession III, lot 2, owned by this company, was shut down in March, 1921. John A. McLean, 316 Moffatt Block, Detroit, Mich., is president of the company.

Long Lake.—Loughborough township, concession IX, lot 11. This is the property on Long lake, Frontenac county, first worked by O'Brien and Fowler in 1920. From December 12, 1920, until the latter part of February, 1921, Sherman Orser and Dr. S. C. Wilson shipped a few carloads of feldspar from one of the veins. William Raymond was foreman.

Rinaldo McConnell of Perth, Ont., worked during 1921 on two feldspar veins in Bathurst township:

Kirkham.—Bathurst township, concession VII, lot 3. This deposit has been mentioned in previous reports. Work was carried on intermittently during the early part of 1921, and a force of ten men was employed from May to August 12, since which date the property has lain idle. James Benton was foreman.

Keays.—Bathurst township, concession IX, lot 20. On August 12, Mr. McConnell began to prospect a vein of pink feldspar, about 28 feet wide, in syenite, on the farm of William J. Keays. Drilling was done by hand with a force of six men until work was stopped towards the end of October. The feldspar quarried was shipped from Glen Tay, seven miles from the pit.

The Mount Eagle Feldspar Company, Limited.—In March, 1921, this company acquired the Watson feldspar property near Hybla from Universal Silicates, Limited. It is situated on lot 22, concession VI, Monteagle township, and was first mentioned in the 29th. Annual Report of this Department.

Work was carried on until July 28, since which time nothing further has been done.

"No. 1" deposit is an irregular pegmatite vein containing feldspar, considerable quartz and some graphic granite. This was the deposit work by Universal Silicates, Limited. The open-cut on the vein is about 38 feet long, 28 feet wide and from 15 to 20 feet deep. A few small pieces of euxenite[1] have been found in this vein.

"No. 2" deposit lies north of No. 1. Here, an open cut, approximately 55 feet long, 20 feet wide and from 15 to 30 feet deep, has been made in the side of a hill; from the inner face of the cut an adit 95 feet long has been driven into the hill on the vein. At the portal the vein contains from 6 to 8 feet of good feldspar, but at one point in the adit it widens to 12 feet. The feldspar above the adit has not been stoped.

The machinery on the property includes a Leonard and Son locomotive-type boiler, 42 inches diameter and 17.3 feet long, an Ingersoll-Sergeant compressor; a Jenckes hoist, about 7 inches by 9 inches, and a derrick.

The head office of the company is at 327 Union Building, Cleveland, Ohio. J. O. Brown, Cleveland, is president; M. B. R. Gordon, manager; and Joseph C. Duval, superintendent.

Orser-Kraft Feldspar, Limited.—The address of this company is Box 266, Perth, Ont., and the officers are now as follows:—president and manager, Sidney H. Orser, Perth, Ont.; vice-president, Edward P. Erion, Buffalo, N.Y.; treasurer, Leo B. Seitz, Buffalo; secretary, Miss Dencie M. Orser, Perth; directors, C. G. Grauer, Buffalo, N.Y. and Gustav Metz, Buffalo, N.Y. In 1921 the company mined feldspar from the *John Burns*, *William J. Keays*, and *Morrow* properties, all of which were mentioned in the Thirtieth Annual Report, and also opened a new deposit on the *Alex. Palmer* property.

The *Burns* deposit is in Bathurst township, concession III, lot 2. Three men were employed here drilling by hand until March, 1921.

The *Keays* is located in Bathurst township, concession IX, east half of lot 21. In January, 1921, Orser-Kraft Feldspar, Limited, began to test a large vein of white feldspar on this property and worked intermittently until autumn. The vein has a northeasterly strike.

The *Morrow* mine is in South Sherbrooke township, concession V, lot 13. Mining was continued at this feldspar deposit until October 31, 1921, when market conditions made a shut-down necessary. From 5 to 12 men were employed under superintendent Elwood Orser. Euxenite[1] is still found in this quarry.

Pennsylvania Pulverizing Company.—This company, with headquarters at Lewiston, Pa., operated two properties known as the *Woodcock* and *Robinson*, respectively.

The first mentioned is located in Monteagle township, concession VIII, lot 17. In September, 1921, stripping was commenced on a vein of feldspar on the farm of *Harvey Woodcock* near Hybla. When last inspected (Oct. 13, 1921), five men were engaged in stripping the vein at a point where the merchantable feldspar appeared about 30 feet wide. The strike of this vein is about 60 degrees. At two places in the portion stripped, some beautiful green feldspar (microcline?) has been found; in one place, the green spar is interlaminated with white feldspar, and in another with red orthoclase. The prospecting is being carried on under the direction of William J. Woods, Lewiston, Pa., assistant general manager of the company, and Robert H. Thompson, Hybla, Ont., superintendent.

The *Robinson* prospect is located in Bedford township, concession 11, lot 30. Harry J. Cain of Tichborne, Ont., has stripped a feldspar vein on the John Robinson farm. No shipments were made.

Rock Products Company.—The Rock Products Company, whose feldspar-grinding plant is in Silica, Ohio, carried on work in 1921 at the three feldspar properties mentioned below. A. G. Minehart, Nicholas Building, Toledo, Ohio, is treasurer and manager of the company.

1.—During January the company commenced to test a vein of feldspar on the farm of *William D. Noonan*, lot 18, concession IX, Bathurst township. After several cars had been shipped, work was discontinued in April.

2.—Afterwards the company opened a new deposit on the farm of *James Keays* in the west half of lot 21, ninth concession of Bathurst township. The feldspar here is of a pale pink colour and occurs in syenite in a vein striking N. 20 degrees E. (magnetic). At the time of last inspection (January 4, 1922), the main pit measured 53 feet long, 23 feet wide, and 24 feet deep; 20 feet north of this pit is another 48 feet long, 28 feet wide, and 8 feet deep. Both pits are on the same vein.

---

[1] Euxenite, a Radio-Active Mineral, by Willet G. Miller and Cyril W. Knight, Ont. Dept. Mines, Vol. XXVI, pp. 314-317.

The plant consists of a Clyde Iron Works vertical tubular boiler, 8 feet 4 inches long and 42 inches in diameter, a friction-drum hoisting engine, and an 85-foot steel derrick with a 70-foot steel boom. From 12 to 15 men were employed here under superintendent James Benton. The mine post office address is R.R. No. 1, Balderson, Ont.

3.—For a few weeks during the autumn the company also had three men at work on a feldspar prospect near Tichborne, owned by *Charles Clobridge* of that village, and situated in lot 24. concession I. Hinchinbrooke township.

Storrington Feldspar Co., Limited.—Storrington township, concession XIII, lot 8. This company was incorporated in May, 1921, to work the Alexander Teeples feldspar property, mentioned in the Thirtieth Annual Report of the Ontario Department of Mines. The capitalization of the company is $100,000, and the officers are: president, Dr. D. A. Coon, Elgin, Ont.; vice-president, Albrecht Hasselbring, Flint, Mich.; secretary and treasurer, C. G. Walton, Elgin, Ont.; directors, William S. Myhill, Worthington, Ont., and H. A. Coon, Calgary, Alta.

As the vein of feldspar is on the south shore of Upper Rock lake at a point where no road is available in the summer, it was decided to transport the spar to the railway across a chain of lakes. Accordingly, a trestle and tramway, 940 feet long, was built from the vein to the shore of Upper Rock lake; a dam was constructed between Upper Rock lake and Lower Rock lake to hold the water in the former; the creek connecting Upper Rock and Stonehouse lakes was dredged out, and a canal dug between Stonehouse and Little Stonehouse lakes. At Little Stonehouse lake the spar will be unloaded from two scows carrying six tons each and lifted to the railways cars on the company's siding. This siding is on the Toronto-Ottawa line of the Canadian National Railways at a point 69.5 miles west of Ottawa. When this preliminary work had been completed the demand for feldspar suddenly ceased, and work had to be stopped in September. C. G. Walton of Elgin was superintendent.

The writer took a sample of this feldspar, which is white in colour, and the analysis obtained by the Provincial Assayer was as follows:—silica, 70.74 per cent., lime 0.68 per cent., soda. 2.96 per cent., potash, 10.46 per cent.

Vanluven.—Loughborough township, concession XII, west half of lot 3. On this lot Albert Vanluven of Holleford, Ont., had six men at work during December and part of January, 1922, prospecting a vein of feldspar which outcrops on the shore at the east end of Fourteen Island lake.

Verona Mining Company.—In Monteagle township, concession VII, lot 18, this company, a subsidiary of the Pennsylvania Feldspar Company, Philadelphia, Pa., has been for the past two years, quarrying feldspar near Hybla, Ont.

When last inspected in October, 1921, the pit on the Peter McDonald farm had the following approximate dimensions:—330 feet in length, 32 feet in width and 18 feet in depth. The vein strikes S. 75 degrees E. and is in a dark green gneiss with light-colored bands. All drilling is done by hand.

At one point in this vein in an area about two feet wide and six feet long, a highly radio-active mineral occurs. This portion of the vein contains feldspar, quartz (considerable of which is smoky), titanite, a black mineral (euxenite?), and a brownish black mineral; the last two minerals, whose composition has not been determined, seem to carry the radium.

The company has also done a small amount of work on the adjoining Sutherland farm.

The officers of the Verona Mining Company are:—president, S. Harry Worth; secretary and treasurer, M. Moore; general superintendent, G. V. Baker; resident superintendent, Walter B. Couch, Hybla, Ont., foreman, John Moran, Hybla, Ont. The head office of the company is at 404 Harrison Building, Fifteenth and Market Streets, Philadelphia, Pa.

Fluorspar

Wallbridge.—On the west half of lot 1, concession I, Madoc township, the Wallbridge brothers did considerable trenching and sank three prospect pits during 1921. On May 22, 1922, a two-compartment shaft was started on one of the fluorspar veins discovered during the previous year's prospecting operations, and when the property was visited on June 23, the shaft was 27 feet in depth with seven feet of fluorspar in the bottom and about 80 tons on the dump.

Gold

Cobalt Frontenac.—The Cobalt Frontenac Mining Company, Limited, owns about 1300 acres of mining land in Lennox and Addington county. The mine, formerly known as the Golden Fleece, is on Lots 24 and 25, concession VI, Kaladar township.

There are two inclined shafts on the property. The south shaft is 80 feet deep, with 90 feet of lateral work at the bottom. The north shaft, 400 feet from the south shaft, is 100 feet deep, with 350 feet of lateral work at the bottom. A winze, 68 feet in depth has been sunk from the 100-foot level.

The cyanide addition to the mill was completed early in 1922. The mill has an estimated capacity of 150 tons every 24 hours and includes a 14 by 24-inch jaw crusher, 10 stamps, a 5 by 16-foot tube mill, a Dorr duplex classifier, one 12 by 32 thickener, three 20 by 14 agitators followed by three 12 by 32 thickeners. The company owns and operates its own hydro-electric plant on the Skootamatta River. The power plant has a rated capacity of 600 horse power.

The officers of the company are:—Noah Dyment, Guelph, president; M. E. Fletcher, Hamilton, vice-president; D. H. Fletcher, Flinton, general manager.

Ore Chimney.—The Ore Chimney Mining Company, Limited, has developed a waterpower on the Skootamatta river at O'Donnel's rapids, near Northbrook. Nine dams have been built, and the water has been raised 18 feet at the rapids. The river has been diverted through a power canal 400 feet long, and has a head of 55 feet. The penstock is a stave pipe, 240 feet in length and 7 feet in diameter, and at the lower end has a surge tank. The penstock will supply two Wm. Hamilton turbines of 625-horsepower each, and controlled by Woodward governors. The electric equipment will be supplied by the Canadian General Electric Company. One generator has been delivered, and the other purchased for delivery this coming winter.

The generators are 400-k.w., and will generate power at 2,200 volts, which will be stepped up to 6600 volts by three single-phase transformers, and transmitted three miles to a transformer house at the mine and stepped down to 550 volts for use in the mine and mill.

No mining has been done since 1917, but it is expected that some work will be done in 1922. A cyanide plant is being added to the mill.

The company is capitalized at $1,200.000, and has offices at Northbrook, Ont., and at 700 Main Street, Buffalo, N.Y. The officers are:—president and manager, Anson E. Fletcher, Northbrook, Ont., vice-president, Edward Zaremba, Buffalo, N.Y.; secretary and treasurer, S. G. Both, Northbrook, Ont.; directors, Anson E. Fletcher, Northbrook Ont.; Edward Zaremba, Buffalo, N.Y.; Edward Smith, Buffalo, N.Y.; S. G. McKay, K.C., Woodstock, Ont.; A. Bauer, Waterloo, Ont.; John M. Fletcher, Buffalo, N.Y.; A. E. Cumming, Buffalo, N.Y.; Fred Slater, Woodstock, Ont.; Charles Zinn, New Dundee, Ont.; Charles Siple, Woodstock, Ont.; F. E. Misener, Hamilton, Ont. C. N. Thompson, until recently at the Galetta lead mine, is mine captain and J. R. Mougin is mill superintendent.

Graphite

Black Donald.—The mine and mill of the Black Donald Graphite Company, Limited, at Whitefish Lake was in operation only for the first three months of 1921. Market conditions in the graphite industry did not improve sufficiently during the year to enable the company to resume operations.

During the three months 1500 tons of ore of an average grade of 65 per cent. graphite were mined. The new mill using the oil flotation process has a capacity of 12 tons per day, and produces a flake graphite with a 95 per cent. carbon content.

An average of 54 men was employed. The officers are:—R. F. Bunting, president and treasurer; R. A. Telfer, secretary; John Patno, superintendent.

Gypsum

Ontario Gypsum Company Limited.—This company operated mines and calcining plants at both Caledonia and Lythmore, and a plaster board mill at Caledonia. During the year 1921 work was carried on continuously at the mine, mill, and plaster board plant at Caledonia. Mining was confined to the second or 65-foot level, the work being principally to the east and north of the incline, with some work to the west. An average of 90 men was employed in the mine, mill and plaster board plant. John Renwick was mine foreman, L. V. Robinson, mill foreman, and H. Bonnell, foreman of the board plant.

At Lythmore the shaft was sunk to the second level (115 feet) and mining carried on for a short time at the 91-foot and 115-foot levels. Gypsum from the second level, being of the white variety, was shipped to Paris, Ont., for the manufacture of alabastine. The mill was in operation for a time on gypsum shipped from Caledonia together with gypsum mined from the upper bed of the Lythmore mine. An average of 25 men was employed under W. A. Parkhurst, superintendent and Jos. Marks, foreman.

A total of 84,765 tons of gypsum was taken from the Caledonia and Lythmore mines during the year 1921.

The officers of the company are:—president, Whitney G. Case, 36 Main St. Buffalo, N.Y.; vice-president, O. W. Whitby,. Paris, Ont.; secretary-treasurer, Robert E. Haire, Paris, Ont. In addition the following are directors:—Jas. R. Inksater, Paris, Ont.; W. G. Case, Buffalo, N.Y.; A. J. Parkhurst, Caledonia, Ont., general manager is Robert E. Haire, Paris, Ont., and general superintendent, A. J. Parkhurst, Caledonia, Ont. The head office of the company is at Paris.

Iron Pyrites

Sulphide.—The mine and chemical works of the Nichols Chemical Co., at Sulphide operated at reduced capacity during 1921.

The iron pyrites treated amounted to 13,800 tons, 1,000 tons of which came from the stock pile. Ore from underground came principally from the north vein on the fifth and sixth levels. During the year a winze, 120 feet deep, was sunk, from the sixth to the seventh level.

In the chemical works, nitric, sulphuric and hydrochloric acids were manufactured in reduced quantities.

An average of 85 men was employed. W. H. De Blois is manager.

Lead

A syndicate of Arnprior people, represented by C. N. Thompson, formerly of the Kingdon Mining, Smelting and Manufacturing Company, took an option on lots 1 and 2, Block A, Tudor township, adjoining the old Hollandia mine. After performing a small amount of work the option was allowed to lapse.

Frontenac.—The Frontenac lead mine near Perth Road has again changed hands, and is now owned by the Northern Lead Company, Limited, of which the president and managing director is J. B. Bell of 232 St. James Street, Montreal. Some prospecting work on the surface was done in 1921.

Kingdon.—The Kingdon Mining, Smelting and Manufacturing Company, Limited, at Galetta, Ont., operated continuously throughout the year 1921. Underground work was curtailed for a month at the last of the year owing to the erection of a steel head frame and changes in the surface works.

During the year 1921 mining was carried on at the second, third and fourth levels. Stoping was done between the second and third levels and between the third and fourth levels. Drifts on the third level were driven 88 feet to the east and 182 feet to the west making the faces 568 feet and 591 feet respectively from the main shaft. On the fourth level drifts were extended 378 feet to the east and 383 feet to the west and were at the end of the year 656 feet and 659 feet respectively from the main shaft. From a point on the fourth level 210 feet west of the main shaft a winze was sunk to a depth of 130 feet. A new level will be made at the bottom of the winze and connected with the main shaft.

In December 1921, a steel head frame, 68 feet high was erected at the main shaft by the Dominion Bridge Company of Montreal. A new Marsh hoist driven by a 90 horse-power motor was installed to handle a two-ton skip.

Underground the ore is dumped from mine cars into the skip. When hoisted the rock is dumped automatically upon a 2-inch Ross grizzly from which the under size goes to a 200-ton bin in the shaft house. The oversize is fed to a 12-inch by a 20-inch jaw crusher and thence to the bin with the undersize from the grizzly. Through a hopper the rock passes to a 24-inch endless belt which in turn delivers to an 18-inch endless belt set at an angle of 12 degrees. The latter belt is driven from a Ding magnetic pulley. Rock then passes to a second Ross grizzly set at ¾-inch and the undersize goes to a 175-ton mill bin. The oversize is fed to a 5-inch by 15-inch Sturtevant crusher and thence to the mill bin.

The following changes have been made in the mill:— trommels have been replaced by Mitchell vibrating screens (three-sixteenth-inch and three-thirty-second-inch with a one-half-inch to be added later) ; the oversize from the three-sixteenth-inch screen goes to rolls set at one-half-inch and thence to a bucket elevator for return to the main circuit; the undersize falls directly on the three-thirty-second-inch screen, and the oversize from this screen passes out as feed for a James automatic jig; the undersize from the three-thirty-second-inch goes to a settling tank and thence to a James sand and slime tables.

The head office of the company is at 314 Beaver Hall Hill, Montreal, Que. The officers of the company are:—president, Chas. M. Robertson, Montreal, Que.; secretary-treasurer, John J. Milne, Montreal, Que.; managing director, A. G. Munich, Montreal, Que.; C. H. Thompson was superintendent until October 30, 1921, when he was succeeded by R. R. Rose, Galetta, Ont. F. A. Warren was smelter superintendent.

An average of 110 men was employed during the year.

Mica

Acton.—In January, 1921, J. U. and C. J. Acton of Gananoque, began to prospect a mica showing in lot 3, concession IV, Sherbrooke township. The vein is alongside the Canadian Pacific railway and about half a mile east of Bolingbroke station. The surface rights of the property belong to one Dowdell and the mining rights to the Matheson estate.

When inspection was made on Februrary 17 five men were engaged in sinking a pit, which was then about twelve feet deep.

On April 27, 1921, Acton Mines, Limited, was incorporated with a capital of $100,000 presumably to work this prospect. The head office of the company is in Gananoque.

Howes and Folger.—During the summer, Harry J. Cain of Tichborne mined mica on a small scale from several shallow pits east of Eagle lake and about a mile and a half northwest of Tichborne. Some of these pits were on the farm of David J. Howes, lot 28, concession II, Hinchinbrooke township, and the others were on lot 27, concession II, Hinchinbrooke, one of the parcels of land owned by the Folger estate. All of the veins worked were narrow.

Lacey.—The Lacey mica mine near Sydenham, was worked during all of 1921 by the Loughborough Mining Company, Limited. This mine still contains large reserves of mica.

When the last inspection was made in September the westerly part of the main vein was being stripped in preparation for stoping. An 8¼ by 10-inch Canadian-Ingersoll-Rand hoisting engine, equipped with a drum and a winch head, is used in connection with a cableway and carrier to handle the material removed from this part of the vein. A force of 16 men was employed.

George W. McNaughton, Sydenham, Ont., is manager and Richard Smith, superintendent.

Molybdenite

American Molybdenites, Limited.—The only molybdenite deposit in the province on which any work was done in 1921 was the one at Wilberforce on the Irondale, Bancroft and Ottawa branch of the Canadian National Railways. The property is on lot 32, concession XV, and lot 32, concession XVI, township of Monmouth. The Molybdenum Products Company, Limited, completed a concentrating mill on the property in December, 1918, but did not mill much ore. All work was stopped in the spring of 1919.

American Molybdenites, Limited, was incorporated, May 2, 1917 with a capitalization of $1,000,000 to work the deposit. The head office of the company is at 42 Toronto Arcade, Toronto, and the officers are:—president, W. J. L. McKay, 466 West Marion Street, Toronto; vice-president, P. J. Dwyer, Toronto; secretary, J. J. Gray, Toronto; directors:—William Flavelle, Lindsay; A. W. Marsh, Niagara Falls, Ont.; A. J. Reid, Sheffield, Eng.; H. T. Bush, Port Hope, Ont. The new company began work in March, 1921, with a small force of men. Some portions of the deposit were open-cut, but most of the work consisted in making alterations in the mill.

Mr. Peters was manager until September, when W. E. T. Barton took charge. The post office address for the mine is Wilberforce, Ont.

Talc

Connolly.—In February, 1921, through the failure of Gilchrist and Company, of New York, the lease of the Connolly property, held by the Anglo-American Talc Corporation, Limited, reverted to the owners. A new company known as the Asbestos Pulp Company was formed. This company has a capitalization of 500,000 shares par value $1.00; 350,000 of the shares are common stock and 150,000 preferred. The officers of the company are: H. B. Hungerford, Belleville, president; A. Gelinas, Montreal, vice-president; P. McNiven Bennie, Belleville, secretary-treasurer.

Additions to the mill include a crusher, 12 inches by 15 inches, a dryer with a capacity of 50 tons per day, two Griffin mills, screens and new blow rooms. The treatment process of this company now includes a sifting and air-flotation plant at Belleville.

George H. Gillespie and Company.—The Gillespie talc mill at Madoc was idle during January and was operated during the remainder of the year, but not at capacity. Full production was resumed in May, 1922. L. Ashley is mill superintendent.

Henderson.—The new main hoisting shaft at this talc mine has been completed to the 200-foot level. The production of ore during the year was maintained at a rate sufficient to supply the requirements of the Geo. H. Gillespie Company. E. Phillips is superintendent.

Price.—The Price farm, being the east half of lot 15, concession XIV, Huntingdon township, was prospected during the early part of 1922 by H. B. Hungerford of Belleville. Three hundred and twenty-five feet of trenching was done, and in June a shaft was down 20 feet.

Metallurgical Works

Algoma Steel Corporation.—In 1921 the Algoma Steel Corporation's blast furnaces at Sault Ste. Marie ran as follows: No. 1 furnace, 319 days; No. 2, 205 days; No. 3, 278 days; No. 4 was idle all year.

The staff at the furnaces remains as before, viz.: James H. Bell, blast furnace superintendent; James Dale, assistant blast furnace superintendent, and Harry Hitchens, blast furnace master mechanic.

Canadian Furnace Company.—The blast furnace of the Canadian Furnace Company at Port Colborne was operated from the beginning of the year to April 24, 1921, and employed 160 men.

From ores imported from the United States 32,405 tons of pig iron was produced. In December the work of relining the furnace and stoves was begun.

The officers of the company are: president, F. B. Baird: first vice-president and treasurer, Harry Yates: second vice-president, C. A. Cowan; secretary, Frederick Slee; superintendent, G. J. Higgins.

Coniagas Reduction Refinery.—The refinery of the Coniagas Reduction Company, Limited, at Thorold worked throughout the year on the reduction of ores from the Cobalt mines and closed down at the beginning of 1922 for alterations. An average of 105 men was employed during the year. During the year 897 tons of ore, concentrates and residues were treated.

A new company, the Coniagas Alkali and Reduction Company, Limited, was formed in June, 1922, to operate the plants in which the following companies are interested: The Coniagas Reduction Company, the Niagara Alkali Company, of Niagara Falls, N.Y., and the Electro Bleaching Gas Company of Niagara Falls, N.Y.

The treatment of ores, concentrates and residues will be continued under a different system by which they will be treated as chlorides and not as sulphates. The blast furnaces, roasting department, bag houses, Cottrell treaters and arsenic refining plant will be replaced by chlorinating furnaces, condensers and stills. The cobalt wet department will be remodelled and continued.

One new furnace building of steel and concrete has been erected and will be ready for operation in September. The building is 44.5 feet by 17 feet and 37 feet high and will have a ground floor, one operating floor and three working platforms above.

The officers of the Coniagas Alkali and Reduction Company are: president, E. D. Kingsley: vice-president, Col. R. W. Leonard: treasurer, Maj. A. L. Bishop; secretary, J. J. Mackan; directors, A. Longwell, T. M. Hicks, J. T. Manson; works manager, F. S. Low: superintendent, D .A. Mutch.

Deloro Mining and Smelting Co., Limited.—The refinery at Deloro was operated during the year at reduced capacity on the ores, concentrates and residue from the Cobalt mines. The silver and arsenic departments worked continuously, but the amount of ore received was considerably less than in the preceding year. The stellite plant was worked at intervals according to the demand and the oxide plant was closed during the year.

Insecticide was manufactured in moderate quantities to establish the product on the market. Arsenate of lead and calcium arsenate were the principal products of this plant, which is operated by the Deloro Chemical Co.

An average of 100 men was employed.

The officers are: president, M. J. O'Brien: managing director, Thomas Southworth: general manager, S. B. Wright, Deloro: general superintendent, R. A. Elliott, Deloro: secretary-treasurer, F. A. Bapty, Deloro.

International Nickel Refinery.—The refinery of the International Nickel Company of Canada, Limited, at Port Colborne operated at reduced capacity from the beginning of the year to August 31. During the remainder of the year the nickel refinery department was operated intermittently.

During the company's fiscal year ending March 31, 1922, 2,716 tons of matte were treated from which, with the metal in process, there was obtained 6,301,000 pounds of blister copper and 3,061,000 pounds of metallic nickel. The palladium and platinum were shipped as concentrate to Bayonne plant, where the gold and silver were also extracted.

Alterations in plant and treatment have been under way during the past 18 months, and when completed will permit of a production of nearly four million pounds of nickel per month, which is almost double the present capacity. To produce this increase the three blast furnaces will be changed from the brick type to the water-jacket type. This change has already been made on one of the furnaces. As the use of the reverberatory furnaces have been discontinued, space is now available for the installation of more calcining furnaces. The capacity of each of the calciners is being doubled by the addition of another deck.

A steel frame building 340 feet by 90 feet is being erected for the production of electrolytic nickel, platinum, palladium, gold and silver. The plant will have a capacity of 400,000 pounds of electrolytic nickel and is expected to be in operation in September, 1922. The treatment of all the ores will then be completed here. The Bayonne plant has been dismantled.

An electric substation will also be erected and transformers installed to provide for an increase of 1,000 h.p. from the Hydro Electric system.

During the seven months of operating in 1921 the average number of men employed was 237, and during the remainder of the year about 100.

The officers at Port Colborne are: general manager, John More; assistant general manager, James Kemp; auditor, E. Lambert.

Ontario Smelters and Refiners.—Ontario Smelters and Refiners, Limited, operated at Welland from the beginning of the year to November 15 except during the month of August.

The residues which had previously been stocked on the property from mines at Cobalt were re-treated and produced cobalt oxide, nickel hydrate, nickel sulphate and insecticide.

A mining claim on Bass lake near the mouth of the Montreal river was operated for a time to procure cobalt ore. During the time the plant was in operation forty men were employed. The officers of the company are: president, Charles Edward Potter; directors, John F. Hickling, M. D. Jenkins, Albert Herbold and James Edward; manager, J. F. Hickling; secretary-treasurer, P. W. Dunbar, Toronto.

Steel Company of Canada.—The Steel Company of Canada, Limited, operated its furnaces at Hamilton at reduced capacity and, owing to the decrease in demand, the stock of pig iron was considerably increased.

"B" furnace, with a capacity of 375 tons per day, was worked during the whole year and "A" furnace, with a capacity of 200 tons, for three and a half months.

The company employed 140 men while both furnaces were in operation and an average of 90 during the balance of the time.

R. G. Wells is works superintendent, and H. G. Hilton superintendent of blast furnaces.

Quarries and other Excavations

A large number of stone quarries and pits for obtaining clay, sand and gravel were inspected during 1921. A list of these is given below by counties and districts, alphabetically arranged. A glance at this list will show how widely spread are these essential materials of construction. Speaking generally, there are few parts of settled Ontario where they do not occur in quantity sufficient to supply local demands, while in many places the deposits are large enough to be drawn upon for the needs of other localities within transportable distances.

In the extreme southwestern part of the Ontario peninsula, say in the counties of Kent, Essex and Lambton, the supplies of gravel suitable for road and construction work are scanty, and recourse is had to dredging in the bed of the St. Clair river, particularly the upper portions, for gravel and sand brought down by the currents from Lake Huron and deposited in the river as shoals and gravel banks. The interests of navigation require dredging to be annually carried on at Sarnia and Point Edward, and most of the material recovered there is coarse and of good quality, and in demand on both sides of the river. The extensive operations which have been carried on at these points have much reduced the accumulations of ages, and suggest the advisability of conserving the remaining supply as much as possible for use on the Canadian side.

The list does not comprise all the quarries and excavations operated in the Province but not only those actually visited and inspected during the year. It will be observed that a number of the counties are not included, it being found impossible to cover all the operations within the twelve months.

QUARRIES INSPECTED DURING 1921.

County or District.	Operator	Address	Location	Average No. Employees	Product
Algoma	Dominion Mines & Quarries, Ltd.	McLennan	East Neebish Island	45	Quartzite, coarse and screened.
"	Wright & Co.	Sault Ste. Marie	S.E.¼, S.½, lot 12, Con. II. Deroche	14	Quartzite.
Bruce	John S. Cook & Son	Wiarton	lot 7, Con XXIV., Amabel	..	Limestone.
"	Sam Vogan	Wiarton	Wiarton	..	Lime.
"	Hydro Electric Power Commission	Walkerton	Brant Twp	38	Crushed Limestone for cement.
"	Toronto Plaster Co.	Teeswater	Teeswater	16	Hydrated lime. .
Carleton	E. D. Brule & Sons	Billings Bridge	Bank of Rideau Canal, Gloucester Twp	25	Crushed and screened limestone for roads and concrete.
"	Campbell & Williams	Bell's Corners	Nepean Twp	6	Sandstones for building purposes
"	Farmer Construction Co.	23 Lorne Ave., Ottawa	Vernon, Osgoode Twp	18	Crushed and screened limestone for roads.
"	Central Experimental Farm	Ottawa	Ottawa	12	Road material for experimental Farm.
"	J. I. Garvock	136 Lewis St., Ottawa.	Cor. Willow & Preston Sts., Ottawa	12	Limestone.
"	Foster & Cram	278 Echo Drive, Ottawa	Bank of Rideau Canal, Gloucester Twp	8	Limestone.
"	Foster & Cram	278 Echo Dr., Ottawa.	City View Quarry	12	Crushed and screened limestone
"	Mahoney & Rich	83 Bank St., Ottawa.	lot 3, Con. II., Gloucester	16	Crushed and screened limestone.
"	City of Ottawa Improvement Commission	c/o Superintendent Fraser Bldg. Ottawa	Cor. Carlington Ave. and Le Breton St.Ottawa	20	Crushed and screened limestone Crushed and screened limestone
"	Ottawa Suburban Roads Commission	Thistle Bldg., Wellington St., Ottawa	lot 16, Con. II, Nepean (Acres Quarry)	20	Crushed and screened limestone.
"	Ottawa Suburban Roads Commission	Thistle Bldg., Welli g ton St., Ottawa	lot 3, Con. III, Gloucester	12	Crushed and screened limestone.
"	H. R. Robillard & Sons	195 Nicholas St., Ottawa	McLaren Quarry, Gloucester Twp	10	Limestones for building, crushed limestone and lime

QUARRIES INSPECTED DURING 1921—*Continued.*

County	Operator	Address	Location	Average No. Employees	Product
Carleton	A. G. Perley	155 McLaren St., Ottawa	Rideau Canal, Gloucester Twp.	12	Crushed and screened limestone for roads
"	Richardson & Henry	83 Bank St., Ottawa	Con. II, Nepean	10	Crushed and screened limestone for roads..
Dundas	F. M. Eagleson	Winchester	Mountain Twp.	20	Crushed and screened limestone for roads.
"	F. Milligan	Iroquois	Lot 1, Con. II, Edwardsburg	20	Crushed and screened limestone for County roads.
Essex	Brunner Mond Canada, Ltd.	Amherstburg	Lots 6, 7, 8, Con. I, Anderdon; Lots 2, 3, Con. II, Anderdon	29	Limestone for chemical works.
Frontenac	County of Frontenac	R.R. No. 1, Kingston	Con. II. Pittsburgh	10	Crushed and screened limestone
"	McGinnis & O'Connor	Portsmouth	Con. I, Pittsburgh	40	Crushed and screened limestone for roads..
"	McGinnis & O'Connor	Portsmouth	lot, 3 Con. VI, Pittsburgh		Granite for roads.
"	Roddy & Monk (3 quarries)	Kingston	Kingston	9	Building and crushed limestone.
"	Robt. Wallace & Sons	Kingston	Kingston		Limestone for building.
Grey	Stewart Chalmers	Owen Sound	Owen Sound	3	Dolomite quarry, and lime kilns.
"	Davis & La Pierre	Owen Sound	Owen Sound	4	Linestome for building.
"	McPherson & Hicks	Owen Sound	Owen Sound	2	Limestone for building.
"	Alex. L. McKay	2 Brown's Ave Toronto.	Owen Sound	9	Limestone for building.
"	James Keeling	Owen Sound	Owen Sound	4	Limestone for building.
"	Oliver-Rogers Stone Co., Ltd.	Owen Sound	Owen Sound	14	Limestone.
"	City of Owen Sound	Owen Sound	Owen Sound		Limestone.
Grenville	Grenville Crushed Rock, Ltd.	Oxford Mills	lots 8 & 9, Con. IV, Oxford	65	Crushed and screened limestone for ballast.
"	Department of Public Highways of Ontario	c/o Resident Engineer, Gananoque	lot 28, Con. I, Augusta	24	Crushed and screened limestone for Provincial Highways.
"	Department of Public Highways of Ontario	Prescott	Windmill Point	24	Crushed and screened limestone for Provincial Highways.
"	W. J. Woodland & Co.	Cardinal	lot 10, Con. I, Edwardsburgh	12	Crushed and screened limestone for roads.
Haldimand	County of Haldimand	c/o Road Superintendent, Hagersville	lot 5, Con. I, Dennis (Dunn Quarry)	14	Crushed and screened limestone for roads.

Haldimand	Hagersville Quarries, Ltd.	Hagersville	lot 13, Con. XIII, Walpole	27	Crushed stone for roads and concrete.
“	Hagersville Crushed Stone Co	Hagersville	S.W.½, lot 28, Con. I, Oneida	25	Crushed stone for roads and concrete.
“	Hagersville Contracting Co.	Hagersville	lots 13, 14, Con. XIII, Walpole	32	Crushed stone for roads and concrete.
“	Department of Public Highways of Ontario	c/o Resident Engineer, Cayuga	Quarry near Byng, Dunn Twp	2	Limestone.
“	John Webber, Sr.	R.R. 9, Dunnville	lot 22, Dunn Twp	2	Limestone for roads and concrete.
Halton	Christie, Henderson Co., Ltd.	Kelso		24	Grey Lime.
“	S. H. Hurst	Limehouse.	lot 21, Con. V, Esquesing.	4	Building stone.
“	D. Robertson & Co.	Milton		23	Lime and building stone.
“	Toronto Lime Co.	Limehouse		19	Lime and building stone.
Hastings	Canadian Marble Co., Ltd.	18 Toronto St., Toronto	lots 30, 31, East Hastings Rd., Dungannon Twp		Marble quarry.
	Canada Cement Co.	Belleville	Point Anne	..	Limestone for cement.
“	Thos. & Wm. Morrison	Bancroft	lot 24, Con. V. & VI., Wollaston	30	Granite for monuments.
“	Point Anne Quarries	Point Anne	Thurlow Twp.	4	Limestone.
“	Paddock & McCrow	R.R. 4, Belleville	lot 24, Con. I, Thurlow	30	Crushed and screened limestone for roads.
“	Department of Public Highways of Ontario	c/o Resident Engineer, Napanee	lot 30, Con. II, Tyendinaga	24	Crushed and screened limestone.
“	Department of Public Highways of Ontario	c/o Resident Engineer, Napanee	lots 16, 17, Con. III, Thurlow	15	Crushed and screened limestone.
“	H. T. Routley	109 Lytton Blvd., Toronto	lots 14, 15, Con. I, Thurlow	23	Crushed and screened limestone.
“	Wm. Vearwith	Bancroft	lots 3, 4, 5, Con. VIII, Faraday	..	Lime.
Lanark	W. H. Cameron	Box 65, Carleton Place	Ramsay Twp.	5	Crystalline limestone for lime.
“	Jas. Bedard & P. Pauline	Perth	lot 26, Con. X, N. Elmsley	2	White Sandstone.
“	Robt. McIlvenna	Smiths Falls	S. Elmsley Twp.	5	Limestone for roads.
“	County of Lanark	c/o Road Superintendent, Perth	lot 24, Con. IX, Beckwith	..	Granite for roads.
“	County of Lanark	c/o Road Superintendent, Perth	lot 11, Con. XIII, Pakenham	12	Crushed and screened limestone.
“	Department of Public Highways of Ontario	c/o Resident Engineer, Carleton Place	lot 30, Con. VIII, Beckwith	15	Crushed and screened limestone.
“	Town of Smiths Falls	Smiths Falls	Smiths Falls	4	Limestone.
Leeds	Joshua M. Abrams	R.R. 1, Gananoque	lot 6, Con. I, Leeds	3	Syenite paving blocks and monuments
“	Mark Appleby	Gananoque	lots 5, 6, Con. II, Leeds		Granite paving blocks.

QUARRIES INSPECTED DURING 1921.—*Continued.*

County or District	Operator	Address	Location	Average No. Employees	Product
Leeds	City of Brockville	Brockville	Brockville	20	Granite and quartzite for roads.
"	Alex. C. Brown	Lyndhurst	lot 10, Con. IX, Leeds	3	Granite for monuments.
"	Robert Brown	376 Sparks St., Ottawa	lots 9 & 10, Con. IX, Leeds	5	Granite for monuments, etc.
"	G. H. Bryson	Brockville	lot 7, Con. II, Elizabethtown	12	Limestone.
"	Chisholm Wellage Co	Brockville (2 Quarries)	Con. I, Elizabethtown	20	Crushed and screened granite and quartzite for roads.
"	Campbell & Lattimore	Gananoque	W.½ lot 32, Con. IV, Pittsburgh	30	Granite paving blocks, building and monumental stone.
"	R. Gordon	Gananoque	Con. I, Escott	15	Granite paving stones.
"	Town of Gananoque	Gananoque	Gananoque	..	Quartzite for roads.
"	Department of Public Highways of Ontario	Gananoque	(Henderson Quarry) Con. I, Leeds	..	Granite for roads.
"	Street & O'Brien	Gananoque	lot 6, Con. II, Leeds	17	Granite paving blocks.
"	W. Young	Brockville	Con. II, Elizabethtown	3	Granite for roads.
Lennox & Addington	Patrick Bergin	Napanee	lot 19, Con. VII, North Fredericksburg	5	Limestone and lime.
" "	County of Lennox and Addington	Bath	lot 23, Con. III, South Fredericksburg	10	Limestone for roads.
" "	County of Lennox and Addington	Bath	lot 35, Con. I, Ernestown	25	Limestone for roads.
" "	County of Lennox and Addington	Enterprise	lot 45, Con. IV, Camden	20	
" "	Town of Napanee	Napanee	Con. VII, North Fredericksburg	..	Limestone for roads.
Lincoln	J. H. Book	St. Anne's	lot 20, Con. IX, Clinton	11	Limestone for roads.
"	J. W. Bradley	Merritton	lot 17, Con. X, Grantham	12	Limestone for roads.
"	J. A. Miller	Smithville	S.½ lot 6, Con. IX, South Grimsby	15	Limestone for roads.
"	County of Lincoln	c/o Road Superintendent, St. Catharines	lot 10, Con. III, North Grimsby (Grimsby Quarry)	14	Crushed and screened limestone for roads.
"	Department of Public Highways of Ontario	Jordan Village	lot 18, Con. V, Louth	..	Limestone
"	Queenston Quarry Co	St. David's		40	Crushed, monumental, sawed limestone.
Muskoka	Gravenhurst Crushed Granite Co., Ltd	Gravenhurst	Gravenhurst	6	Crushed gneiss.

Ontario	Department of Public Highways of Ontario	Washago	Rama Twp	55	Crushed gneiss
Oxford	American Cyanamid Co.	Beachville	lot 16, Con. III, Oxford N.	23	Crushed limestone for cyanide plant at Niagara Falls.
“	Beachville White Lime Co.	Beachville	Beachville	..	Stone, lime, agricultural line.
“	Standard White Lime Co.	Guelph	Beachville, Guelph	40	High calcium, magnesium and Hydrated lime
Perth	St. Marys Cement Co.	St. Marys		60	Cement.
“	Thames Quarry Co.	St. Marys		25	Limestone.
Peterborough	Ontario Rock Co., Ltd	Havelock	lot 7, Con. VI, Belmont	45	Crushed trap.
Prescott	Barry Construction Co.	Hawkesbury	lot 9, Con. III, West Hawkesbury	15	Crushed limestone.
“	Mooney & St. Denis	Vankleek Hill	McAlpine	12	Crushed limestone.
“	County of Prescott	St. Isidore de Prescott	S. Plantagenet Twp	10	Crushed and screened limestone for roads.
“	County of Prescott	Plantagenet Springs	lot 6, Con. VI, North Plantagenet (Winning Quarry)	17	Limestone for roads.
“	Fred Gamble & Co.	Lancaster	Lot 20, Con. I, Alfred (Quarry near Lefaivre)	12	Limestone for roads.
Prince Edward	County of Prince Edward	Picton	Con. II, Hallowell	16	Crushed limestone for roads.
“ “	County of Prince Edward	Picton	Con. II, Hillier	12	Crushed limestone for roads.
“ “	County of Prince Edward	Allisonville	Hillier	14	Crushed and screened limestone for roads.
Renfrew	J. McTierman	R.R.2, Arnprior	Lot 21, Con. IV., Torbolton	2	Limestone and lime.
“	William Markus, Ltd.	Pembroke		5	Building stone, crushed stone for concrete.
“	Jamieson Lime Co.	Renfrew	lot 5, Con. II, Horton	5	Crystalline limestone and lime
“	Jamieson Lime Co.	Renfrew	Renfrew		Crystalline limestone and lime.
“	Town of Renfrew	Renfrew	Con. II, Horton	8	
“	Standard Chemical Co.	Eganville	Eganville	5	Lime for chemical plants.
Russell	MacDonald & Dibble	Rockland		..	Limestone.
“	Grant Bros.	Casselman	Con. VI, Cambridge	7	Limestone for roads.
“	County of Russell	Bourget	..Con. IV, Clarence	10	Crushed and screened limestoe for roads.
“	County of Russell	Embrun	lot 8, Con. VIII, Russell	10	Crushed and screened limestone for roads.
“	County of Russell	Casselman	Con. VI, Cambridge (Francoeur Quarry)	18	Crushed and screened limestone for roads.
Simcoe	Geo. Higginson & Son	Coldwater	lots 19, 20, Con. XII, Medonte	13	Crushed limestone.
“	Ontario Stone Corp.	Uhtoff	lot 10, Con. IV, North Orillia	27	Crushed limestone.
Stormont	County of Stormont	c/o Road Superintendent, Cornwall	lot 9, Con. III, Finch	25	Crushed limestone for road.
Victoria	Britnell & Co.	Burnt River	lots A, B, Con. VI, Sommerville	18	Crushed limestone.
“	Canada Lime Co.	Coboconck	Coboconk	12	Limestone and lime.

QUARRIES INSPECTED DURING 1921.—*Continued.*

County or District	Operator	Address	Location	Average No. Employees	Product
Victoria	Crushed Stone, Ltd	Kirkfield	lot 49, Con. IX, Eldon	38	Crushed limestone.
"	Toronto Brick Co.	Coboconk	Coboconk	15	Lime.
Waterloo	City of Galt	Galt	On Bank of Grand River	47	Crushed and screened limestone for city streets.
Welland	Township of Bertie	Ridgeway	Bertie Twp.	7	Crushed limestone for roads.
"	Township of Bertie	Ridgemount	Con. VIII, Bertie	5	Crushed limestone for roads.
"	Canada Cement Co.	Port Colborne	Port Colborne	22	Limestone for cement.
"	Township of Humberstone	Humbertone	lot 4, Con. I, Humberstone (near Sherkston)	8	Limestone for roads.
"	E. G. Law	Ridgeway	Bertie Twp.	11	Limestone for roads.
"	J. Pirson	Port Colborne	lot 5, Con. II, Wainfleet	45	Limestone for roads
"	Walker Bros.	Thorold	lot 31, Stamford	22	Limestone for flux and paper making, crushed and screened limestone for roads.
"	County of Welland	c-o Road Superintendent, Welland	lots 3, 4, Con. I, Pelham	10	Limestone.
Wellington	Alabastine Co. of Paris	Elora	Nichol Twp.	35	Hydrated and agricultural lime.
"	Christie Henderson & Co.	R.R. 2, Puslinch	lots 1, 4, Con. I, Puslinch	45	Lime.
"	E. Harvey & Son	Rockwood	Rockwood	10	Limestone & lime.
"	Jas. A. Gow	Fergus	Fergus	6	Crushed limestone.
"	J. Maloney	R.R. 2, Puslinch	lots 34, 35, Front Gore of Puslinch	24	Crushed limestone for roads.
"	Ontario Reformatory	Guelph	Guelph Twp.	70	Crushed limestone for roads.
Wentworth	Township of Barton	Mount Hamilton	lot 13, Con. VI, Barton	12	Crushed and screened limestone.
"	Township of East Flamboro	Rock Chapel		7	
"	Canadian Construction Co.	Hamilton	lot 14, Con. VI, Barton	25	Crushed limestone.
"	Canada Crushed Stone Corporation, Ltd.	Dundas	Dundas	130	Crushed and screened limestone and building stone.
"	Dufferin Construction Co.	305 Brass Bldg., Toronto	On Ancaster Hill	25	Crushed and screened limestone.
"	John Dorr	Ryckman's Corners	lot 13, Con. VII, Barton	7	Crushed and screened limestone
"	Gallagher Lime & Stone Co., Ltd.	R.R. 2, Hamilton	lot 15, Con. V, Barton	5	Limestone and lime.
"	J. N. Middleton	Ancaster	Ancaster	..	Limestone.
"	Jas. Marshall & Sons	R.R. 4, Hamilton	lot 14, Con. VI, Barton	..	Limestone and lime.

"	Department of Public Highways of Ontario	Sheffield	lot 5, Con. VII, Beverley	17	Crushed and screened limestone. for roads.
"	Department of Public Highways of Ontario	Rockton	lot 18, Con. IV, Beverley	..	Crushed and screened limestone for roads.
"	Township of East Flamboro	c-o Township Clerk, Waterdown	Con. II, E. Flamboro	..	Crushed limestone for roads.
"	Towland Construction Co.	Long Branch	lot 12, Con. III, E. Flamboro	30	Crushed and screened limestone.
"	County of Wentworth	c-o Road Superintendent, Hamilton	lot 17, Con. V, Saltfleet (Ferry's Quarry)	6	Crushed and screened limestone
"	County of Wentworth	c-o Road Superintendent, Hamilton	lot 6, Con. IV, W. Flamboro	7	Crushed and screened limestone
"	County of Wentworth	c-o Road Superintendent, Hamilton	lot 1, Con. III, E. Flamboro (near Waterdown)	14	Crushed and screened limestone.
"	County of Wentworth	c-o Road Superintendent, Hamilton	Con. VIII, Barton	12	Crushed limestone.
"	Wentworth Quarry Co., Ltd.	Vinemount	lot 4, Con. V, Saltfleet	18	Crushed and screened limestone

CLAY PITS INSPECTED DURING 1921.

County.	Operator.	Address.	Location.	Average No. Employees.	Product.
Brant	Jackson Bros.	Brantford	Brantford	..	Brick.
Bruce	Geo. Bannerman, Jr.	R.R. 1, Greenock	lots 19, 20, Con. XIV, Culross	9	Brick and tile.
"	Smith Bros.	Port Elgin	Port Elgin	6	Brick.
"	Samuel Wilson & Sons	R.R. 2, Paisley	lot 35, Con. II, Bruce	..	Brick and tile.
Carleton	Merkley's, Limited	Ottawa	Billings Bridge, Gloucester	.. 34	Red brick, shale brick, tile terra cotta and wall tile.
Essex	Ben Broadwell & Son	R.R. 3, Cottam	lot 12, Con. IV, S. Gosfield		Brick and tile.
"	John T. Miner & Son	R.R. 2, Kingsville	lot K, Con. III, S. Gosfield	..	Brick and tile.
"	Windsor Brick & Tile Co.	R.R. 3, Cottam	Con. VI, N. Gosfield	..	Brick, tile, building blocks.
Grey	Meaford Brick Co., Ltd	9 Toronto St., Toronto	lot 9, Con. I, St. Vincent	14	Shale pit.
"	Owen Sound Brick Co., Ltd.	Owen Sound	Owen Sound	..	Brick.
"	John C. Wright	Proton	lot 190, Range II, S.W.T. & S. Road, Artemesia	..	Brick and tile.
Halton	Atlas Brick Co.	Milton Heights	Trafalgar Township	..	Brick.
"	Milton Pressed Brick Co.	Milton	Milton	12	Brick.
"	Halton Brock Co.	Terra Cotta	lot 28, Con. II, Esquesing	18	Brick.
"	Hinde & Philips	Georgetown	Pt. lot 28, Con. II, Esquesing	5	Brick.
Hastings	D. W. Rollins	R.R. 4, Belleville	Thurlow Twp.	4	Red Brick.
Kent	J. Fox	Dresden	Con. III, Gore of Camden Tp.	8	Brick.
"	D. G. McGregor	R.R. 2, Dresden	Con. IV, Gore of Camden	3	Brick and tile.
"	H. W. Parks	Dresden	Con. IV, Gore of Camden	6	Tile.
"	Geo. J. Fox	Box 243, Dresden		5	Red Brick.
Lanark	T. Godfrey & Son	Carleton Place		3	Red Brick.
Lennox & Addington	John Chapman	R.R. 3, Napanee	lot 15, Con. VI, North Fredericksburgh	5 ..	Brick and tile.
Middlesex	J. M. McLoughlin	1044 William St., London	Victoria and Adelaide Sts., London	3	Yellow brick.
"	J. C. Waide	1010 Adelaide St. W., London	Adelaide and Cheapside, London	3	Yellow brick.
"	Warwick Brick Works	647 Grosvenor St., London	West side Elliott St., London	12	Yellow brick.
Peel	Interprovincial Brick Co.	Cheltenham	lot 29, Con. V, Chinquacousy	4	Brick.
"	Alsey Norton	Bolton	lot 8, Con. VII, Albion	..	Tile.
"	Streetsville Brick Co.	Streetsville	lot 3, Con. V, Toronto	5	Brick.
"	Milton Pressed Brick Co.	Streetsville		5	Brick.

Peterborough	Curtis Bros.	Box 949, Peterborough	lot 32, Con. XII, Duoro; Con. XII, Otonabee	24	Red and yellow brick and tile
Prescott	Edwin G. Steele	Vankleek Hill	Part lots 9 & 10, Con. IV, and lot 11, Con. IV, W. Hawkesbury	15	Brick.
Renfrew	Dochart Brick, Tile & Terra Cotta Works	Arnprior	1 mile west of Arupmior	25	Brick, etc.
Russell	Glascow & Mulligan	Russell	Near Russell	12	Red pressed brick.
Simcoe	Coldwater Brick & Tile Co.	Watson Bros., Orillia lessees	Coldwater	..	Brick and tile.
Waterloo	Ott Brick & Tile Co.	Kitchener	Kitchener	15	Yellow brick and tile.
Wentworth	W. H. Cooper	Dundas St., Hamilton.	Dundas St., Hamilton	2	Brick.
"	Canadian Pressed Brick Co.	Sun Life Bldg., Hamilton	lots 1 & 2, Con. IV, Barton	4	Brick.
"	Bartonville Pressed Brick Co.	Sun Life Bldg., Hamilton		5	Brick.
"	Dominion Sewer Pipe & Clay Industries, Ltd.	Aldershot	Aldershot	13	Brick, sewer pipe, tile, and clay products.
"	Hamilton Pressed Brick Co.	Hamilton	Hamilton	5	Brick, sewer pipe, tile, and clay products.
"	Geo. E. Mills	Hamilton	Dundas Road, Hamilton	4	Brick.
"	Ontario Sewer Pipe Co.	Aldershot	Aldershot	10	Sewer pipe, tile, and clay products.
York	Don Valley Brick Co.	Toronto	Don Valley	37	Brick.
"	Price & Smith	Toronto	Greenwood Ave	4	Brick.
"	Standard Brick Co.	Toronto	Greenwood Ave	4	Brick.
"	Sun Brick Co.	Todmorden	Don Valley	7	Brick.
"	Toronto Brick Co.	Swansea	Swansea	2	Brick.
"	A. H. Wagstaff	Toronto	Greenwood Ave	4	Brick.

SAND AND GRAVEL PITS INSPECTED DURING 1921.

County or District	Operator	Address	Location	Average No. Employees	Product
Algoma	Wright & Co.	960 Queen St., Sault Ste Marie	S.W. ¼ of S.W. ¼ Sec. 13, Korah	..	Gravel.
Brant	County of Brant	c-o Road Superintendent, Brantford	lot 1, Con. VI, Burford (Bishopsgate)	..	Gravel.
"	County of Brant	c-o Road Superintendent, Brantford	lot 29, Con. III, S. Dumfries	..	Gravel.
"	County of Brant	c-o Road Superintendent, Brantford	lot 10, Con. X, Burford	..	Gravel.
"	County of Brant	c-o Road Superintendent, Brantford	lot 6, Con. IV, Oakland (Church's Pit)	..	Gravel.
"	City of Brantford	Brantford	lot 7, Con. III, Oakland (Grantham Pit)	..	Gravel.
"	Brantford Sand and Gravel Co.	12 Temple Bldg.,	lot 20, Con. III, Brantford	..	Sand and gravel.
"	J. T. Burrows	Brantford	Brantford	..	Sand and gravel.
"	P. Claney	Centre St., Brantford	Brantford	..	Sand.
"	Johnson Bros	Market St., Brantford.	Echo Place	..	Sand.
"	W. Isenbach	64 Darling St., Brantford	Brantford Twp	6	Sand.
"	Paris Sand and Gravel Co.	R.R. 2, Paris	lot 34, Con. III, S. Dumfries	12	Sand.
"	Town of Paris.	Paris		..	Gravel.
Bruce	County of Bruce	Port Elgin	lot 49, Con. A, Greenock	..	Gravel for roads.
"	Samuel Wilson & Sons	R.R. 2, Paisley	lot 35, Con. VIII, Bruce	..	Gravel.
"	Chas. W. Cottrill	R.R. 2, Paisley	lot 18, Clyde St., Greenock Gore	..	Gravel.
"	Thomas R. Collins	Paisley	Paisley	..	Gravel.
"	Mrs. Thos. Dobson	Paisley	Paisley	..	Gravel.
"	James S. Dewar	Paisley	Paisley	..	Gravel.
"	Peter Meyer	R.R. 1, Greenock	lot 35, Con. I, S.D.R., Greenock	..	Gravel.
"	Duncan McArthur	R.R. 2, Paisley	Lot 11, Con. XX, Greenock	..	Gravel.
"	Vincent Leeson	Paisley	Paisley	..	Gravel.
"	Department of Public Highways of Ontario	Walkerton	Lot 35, Con. I, South Greenock	..	Gravel.
"	Smith Bros.	Port Elgin	Port Elgin	..	Gravel.

Bruce	John Stoddard	Paisley	Paisley	..	Gravel.
"	William Wangler	R.R. 4, Walkerton	Lots 6, 7, Con. I South, Brant	..	Gravel.
"	Andrew Zettler	R.R. 4, Walkerton	Lot 20, Con. I North, Brant'	..	Gravel.
"	Joseph J. Zettler	R.R. 4, Walkerton	Lot 19, Con. II North, Brant	..	Gravel.
Carleton	Fred Carss	R.R. 1, Arnprior	Lot 23, Con. IV, Fitzroy	..	Sand and gravel.
"	Jas. E. Blain	R.R. 1, Arnprior	Lot 22, Con. IV, Fitzroy	4	Sand and gravel.
"	Township of March	c-o Township Clerk, Stittville	Lot 20, Con. III, Huntley (Humphrey's Pit)	..	Sand and gravel.
"	Department of Public Highways of Ontario	c-o Resident Engineer, Renfrew	Lot 27, Con. IX, Huntley	12	Sand and gravel.
"	Department of Public Highways of Ontario	c-o Resident Engineer, Carleton Place	Lot 11, Con. VIII, Goulburn	6	Gravel.
"	Department of Public Highways of Ontario	Carleton Place	Lot 5, Con. I, North Gower (Mitchell Pit)	20	Gravel.
"	Department of Public Highways of Ontario	c-o Resident Engineer, ways of Ontario	Lot 27, Con. IV, (Wallace Pit)	11	Crushed and screened gravel.
"	Department of Public Highways of Ontario	c-o Resident Engineer, Carleton Place	Lot 16, Con. III, North Gower (Brownlee Pit)	10	Sand and gravel.
"	Department of Public Highways of Ontario	c-o Resident Engineer, Carleton Place	Lot 3, Con. II, Nepean (Howe's Pit—)	18	Gravel.
"	County of Carleton	c-o T. H. Byrne, Road Superintendent, Sparks St., Ottawa	Lots 4, 5, Con. IV, Marlborough (Crawford Pit)	20	Gravel.
			Lot 30, Con. IV, Gloucester	6	Gravel.
"	W. J. Donaldson	Arnprior, R.R. 1	Lot 27, Con. III, Fitzroy	..	Sand and gravel.
"	S. R. Rudd	Arnprior	Lot 27, Con. III, Fitzroy	..	Sand and gravel.
"	J. A. Harvey Spratt	R.R. 1, Billing's Bridge	Gloucester Twp	..	Sand and gravel.
"	John Stanley	Stanley's Corners		..	Sand, tile and concrete blocks.
"	St. Jean Bros	Clarkston, via Ottawa	East of Rockliffe Park, Gloucester	..	Sand.
Dundas	J. E. Faulkner	Morewood	Lot 15, Con. X, Winchester	2	Concrete blocks and tile.
"	J. Dagenais	Morewood	Lot 25, Con. XII, Winchester	..	Sand and gravel.
"	S. Fulton	Chesterville	Lot 9, Con. V, Winchester	..	Sand and gravel.
"	Geo. Forrester	Morewood	N½ Lot 15, Con. XI, Winchester	..	Sand and gravel.
"	J. A. McLean	R.R. 1, Chesterville	Lot 9, Con. VII, Williamsburg	..	Sand and gravel.
"	Thos. Featherston	R.R. 1, Chesterville	Lot 2, Con. VII, Williamsburg	..	Sand and gravel.

SAND AND GRAVEL PITS INSPECTED DURING 1921:—*Continued.*

County	Operator	Address	Location	Average No. Employees	Product
Dundas	C. Marcelis	R.R. 2, Chesterville	Lot 21, Con. VIII, Williamsburg	..	Sand and gravel.
"	Township of Williamsburg	c-o Township Clerk, Williamsburg	Williamsburg	..	Sand and gravel.
Elgin	C. A. Caseadden	R.R. 5, Aylmer	Lot 22, Con. VI, Malahide	..	Sand and gravel.
"	County of Elgin	c-o Road Superintendent, St. Thomas	Lot C, Con. VII, Aldborough	..	Gravel.
"	County of Elgin	c-o Road Superintendent, St. Thomas	Lot 2, Con. IV, Yarmouth	..	Gravel.
"	J. M. Hale	Aylmer	Lot 16, Con. V, Malahide	8	Gravel.
"	Township of Malahide	Aylmer	Lot 21, Con. VI, Malahide	..	Gravel.
"	Norman Griswold	R.R. 3, Iona Station	Lot 19, Con. VI, Dunwich	..	Sand and gravel.
"	McColl Bros.	Rodney	Lot C, Con. VI, Aldborough	..	Sand and gravel.
"	D. McAlpine	Dutton	Lot 11, Con. A, Dunwich	..	Sand and gravel.
"	E. Learn	R.R. 5, Aylmer	Lot 19, Con. V, Malahide	..	Sand and gravel.
"	H. Newell	R.R. 4, Aylmer	Lot 35, Con. VIII, Malahide	..	Sand and gravel.
"	Jos. Axford	St. Thomas	Lot 7, Con. III, Yarmouth	..	Sand and gravel.
"	A. E. Ponsford	605 Talbot St., St. Thomas	Lot 17, Con. VIII, Yarmouth	..	Sand and gravel.
"	F. C. Poole	R.R. 4, St. Thomas	Lot 4, Con. VI, Yarmouth	..	Sand and gravel.
"	E. M. Prior	R.R. 4, St. Thomas	Lot 16, Con. IV, Yarmouth	..	Gravel.
"	Geo. Shelley	R.R. 4, St. Thomas	Lot 3, Con. VII, Yarmouth	..	Gravel.
"	Township of Yarmouth	c-o Township Clerk, St. Thomas	Lot 7, Con. IV, Yarmouth	..	Gravel.
Essex	County of Essex	c-o Road Superintendent, Sandwich	Lot 12, Con. III, S. Gosfield	..	Sand and gravel.
"	County of Essex	c-o Road Superintendent, Sandwich	Con. II, Mersea	..	Sand and gravel.
"	J. H. Hillman	Leamington	Con. II, Mersea	....	Sand and gravel.
"	Township of Mersea	Leamington	Con. II, Mersea	..	Sand and gravel.
"	Department of Public Highways of Ontario	c-o Resident Engineer, Kingsville	Lot 1, Con. I, Mersea	..	Sand and gravel.
"	Department of Public Highways of Ontario	c-o Resident Engineer, Kingsville	Lot 12, Con. III, S. Gosfield	..	Sand and gravel.
"	Township of South Gosfield	Kingsville	S. Gosfield Twp	..	Sand and gravel.
"	Windsor Sand and Gravel Co	Leamington	Mersea Twp	7	Crushed, washed and screened gravel; sand.

Frontenac	Kingston Sand and Gravel Co	R.R. 5, Kingston	Lot 34, Con. V, Kingston	7	Sand and gravel.
"	R. G. Johnson	Sunbury	Lot 7, Con. VI, Storrington	..	Sand and gravel.
"	Twp. of Storrington	R.R. 1, Sunbury	Lot 10, Con. VI, Storrington (Sloane Pit)	4	Gravel.
Grey	John J. Carson	R.R. 2, Proton Station	Lots 183, 184, R. III, S.W.T.S.R., Artemesia	..	Sand and gravel.
"	Israel McInnis	R.R. 4, Owen Sound	Lot 8, Con. III, Derby	..	Sand and gravel.
"	Gilbert Martindale	R.R. 5, Owen Sound	Lot 17, Con. III, or IV, Derby	..	Gravel.
"	William Legate	Owen Sound	Con. II, Derby	..	Sand.
"	S. Robert Lee	R.R. 3, Owen Sound	Lot 17, Con. IV, Derby	..	Gravel.
"	George Moore	R.R. 3, Proton Station	Lot 184, R. I, S.W.T.S.R., Artemesia	..	Gravel.
"	Johnson Nelson	Owen Sound.	Lot 10, Con. II, Derby	..	Sand and gravel.
"	Department of Public Highways of Ontario	Durham	Lot 184, R. I, S.W.T.S.R., Artemesia	..	Gravel.
"	John E. Russel Co	Durham	Durham	50	Crushed, washed and screened gravel; sand.
Kent	Township of Howard	Ridgetown	Lot 84, Howard Twp	4	Sand and gravel.
"	Township of Harwich	Blenheim	Lot 13, Con. VI, Harwich	..	Sand and gravel.
"	Township of Harwich	Blenheim	Lot 9, Con. II, Harwich	..	Sand and gravel.
"	Township of Harwich	Blenheim	Lot 16, Con. XII, Harwich	..	Sand and gravel.
"	Township of Harwich	Blenheim	Lot 7, Town Line, Harwich	..	Sand and gravel.
"	Township of Harwich	Blenheim	Lot 22, Con. VII, Harwich	..	Sand and gravel.
"	County of Kent	c-o Road Superintendent, Chatham	Lot 13, Con. IV, Harwich	..	
"	Department of Public Highways of Ontario	c-o Resident Engineer, Kingsville	Lot 10, Con. II, Harwich	..	Sand and gravel.
"	Department of Public Highways of Ontario	c-o Resident Engineer, Kingsville	Lot 17, Con. VI, Harwich	..	Sand and gravel.
"	Department of Public Highways of Ontario	c-o Resident Engineer, Kingsville	Lot 84, Talbot Rd., Howard	6	Sand and gravel.
"	Township of Raleigh	...Charing Cross	South Cedar Springs, Raleigh Twp	..	Sand.
"	Township of Romney	c-o Township Clerk, Wheatley	Romney	..	Sand.
Lanark	James V. Closs	R.R. 1, Lanark	Lot 11, Con. X, Drummond	..	Sand, cement, tile.
"	A. Hammond	R.R. 1, Carleton Place.	Lot 2, Con. XII, Lanark	..	Sand.
"	Mrs. Elizabeth Gillespie	Perth	Lot 5, Con. I, Drummond	..	Sand.
"	Jas. Gibson	R.R. 3, Perth	Lot 16, Con. I, Bathurst	..	Sand.
"	W. J. McColl	R.R. 1, Carleton Place.	Lot 2, Con. XI, Lanark	..	Sand.

SAND AND GRAVEL PITS INSPECTED DURING 1921.—*Continued.*

County	Operator	Address	Location	Average No. Employees	Product
Leeds	Scott & Nicholson	Brockville	Lot 2, Con. 1, Yonge	8	Sand and gravel.
Lennox & Addington	Horace G. Denyes	R.R. 1, Odessa	Lot 16, Con. IV, Ernestown	..	Sand and gravel.
" "	Joy & Son	Napanee	Napanee	..	Sand gravel for cement, tiles, etc.
Middlesex	Edison Blizard	R.R. 6, London	Lot 2, Con. III, London	3	Gravel.
"	Builders Suppy Co.	London	Cor. Elliott & Victoria Sts., London	..	Sand.
"	Henry Tack		Elliott St., London		Sand, concrete blocks.
Norfolk	County of Norfolk	Simcoe	Lot 7, Con. XII, Townsend	14	Gravel.
"	Township of Townsend	c-o Township Clerk, R.R. 1, Simcoe	Lot 16, Con. V, Townsend (Weir's Pit)	10	Gravel...
"	Township of Townsend	c-o Township Clerk, R.R. 1, Simcoe	Lot 8, Com. IX, Townsend (Klein's Pit)	4	Gravel.
"	Township of Townsend	c-o Township Clerk, R.R. 1, Simcoe	Lot 7, Con. IX, Townsend (Kellen's Pit)	3	Sand and gravel.
Northumberland	N. E. Bellyou	R.R. 4, Trenton	Lot 6, Con. 1, Murray	..	Sand and gravel.
"	Town of Campbellford	Campbellford	Raglan St., Campbellford	12	Gravel.
"	P. L. McAuley	Trenton	Lot 5, Con. 1, Murray	..	Gravel.
"	Henry Redden	Campbellford	Campbellford	..	Gravel for concrete.
"	T. H. Slush	River Road, Campbellford	Seymour Township	..	Sand and gravel.
Perth	McKnight Construction Co.	Stratford	Lot 4, Con. II, Ellice	..	Sand and gravel.
"	F. H. McKay	Stratford	Lot 8, Con. VI, Downey	..	Sand and gravel.
Peterborough	W. Brown	R.R. 4, Peterborough	Lot 1, Con. II, Smith	..	Gravel.
"	City of Peterborough	Peterborough	Smith Township	4	Crushed gravel.
"	Jas. Stothart	R.R. 4, Peterborough	Lot 7, Con. II, Smith	5	Crushed gravel.
Prince Edward	Township of Hallowell	c-o Township Clerk, Picton	Cheery Valley Road, Hallowell Twp.	..	Gravel.
" "	Town of Picton	c-o Town Clerk, Picton	Hallowell Twp.	..	Gravel.
" "	West Lake Brick & Products Co.	R.R. 1, Westlake	Sand Banks, Yeo Lake	22	Sand Lime-Brick
" "	Homer White & Co.	Picton	Hallowell Twp.	..	Sand and gravel.
Renfrew	County of Renfrew	c-o Road Superintendent, Pembroke	W½ Lot 16, Con. XII, Renfrew	14	Gravel.

Simcoe	Guy H. Orr	Coldwater	Lot 17, Con. XII, Medonte	..	Gravel.
"	The Sarjeant Co.	Barrie	Barrie	..	Gravel.
"	J. G. Scott	Barrie	Barrie	..	Gravel.
Waterloo	Paul Bergman	Waterloo	Bridgeport	2	Sand and gravel, concrete tile.
"	Cowan Bros.	R.R. 7, Galt	Cedar Creek Rd. and Waterloo Ave.	4	Sand and gravel.
"	J. Huffman	27 Pine St., Kitchener.	King St., Waterloo	..	Sand and gravel.
"	J. K. Forwell	26 Shoemaker Ave., Kitchener	Kitchener	.	Sand and gravel; concrete tile.
"	Chas. Larter	76 Chalmers St., Galt.	Galt	..	Sand and gravel.
"	Sand and Supply Co.	Ayr		4	Sand and gravel.
"	F. S. Scott	Galt	North Dumfries Twp	1	Sand and gravel.
"	J. G. Scott	Barrie		..	Sand and gravel.
"	G. M. Shirk	Bridgeport	Waterloo Twp	5	Crushed and screened gravel.
"	A. Shoemaker	R.R. 4, Kitchener		..	Sand, concrete pipe.
Welland	Benson & Patterson	Stamford	Stamford Twp	8	Sand and gravel; moulding sand
"	Carroll Bros.	Sherkston	On Lake Shore	10	Sand.
"	J. E. Crow	Ridgeville	Lot 5, Con. VII, Pelham	..	Sand and gravel.
"	Empire Limestone Co.	Sherkston	On Lake Shore	8	Sand.
"	Jos. H. Fletcher	Ridgeville	Ridgeville	5	Concrete blocks.
"	Fonthill Sand & Gravel Co.	c-o C. E. McPherson, St. Catharines	Fonthill	3	Sand and gravel.
"	Edgar Metler	R.R. 3, Fenwick	Lot 12, Con. VII, Pelham	..	Sand and gravel.
"	Jacob Page	R.R. 3, Fenwick	Lot 12, Con. VIII, Pelham	..	Sand and gravel.
"	Township of Pelham	Fenwick	Pelham Township	5	Sand and gravel.
"	Ridgeville Concrete Works	Ridgeville	Lot 7, Con. VII, Pelham	3	Sand; concrete blocks.
Wellington	City of Guelph	Guelph	Edinborough Road and Bellevue St., Guelph	5	Gravel.
"	McNamara Bros. and Thornton	Herald Bldg., Guelph	Edinborough Road, Guelph	4	Gravel.
"	W. M. McAllister	Guelph	Victoria Road, Guelph	..	Gravel.
Wentworth	Armstrong Supply Co.	326 Lister Bldg., Hamilton	Burlington Heights	8	Screened sand and gravel.
"	D. J. Bowman	97 Chesnut St., Hamilton		1	Sand and gravel.
"	Crawford Bros.	King & Macklin Sts., Hamilton	King & Macklin Sts., Hamilton	7	Brick, sand and gravel.
"	Hamilton Sand and Gravel Co.	Queen & York Sts., Hamilton	Burlington Heights	4	Sand and gravel.
"	Frid Bros.	Macklin St. and Dundas Road, Hamilton	Macklin St. and Dundas Road, Hamilton	7	Brick, sand and gravel.
"	F. R. Ollman	Macklin St., Hamilton	Macklin St., Hamilton	6	Brick, sand and gravel.

SAND AND GRAVEL PITS INSPECTED DURING 1921.—*Continued.*

County	Operator	Address	Location	Average No. Employees	Product
Wentworth	L. Taylor	R.R. 1, Bartonville	Saltfleet Township	1	Sand and gravel.
"	W. Theaker	Kenilworth and Aberdeen Aves., Bartonville	Kenilworth and Aberdeen Aves., Bartonville	7	Concrete blocks.
York	Township of Saltfleet	c-o Township Clerk, Stony Creek	Lot 31, Con. III, Saltfleet	4	Sand and gravel.
"	Allen Bros	60 Birch Ave., Toronto	Lot 31, Con. A, Scarboro Twp	......	Brick, sand and gravel.
"	Joseph Bennet	145 Caledonia Road, Toronto	Scarlet Road, West Toronto	4	Sand and gravel.
"	M. S. Boehm & Co	13 Humber Rd	Mount Dennis	1	Sand and gravel.
"	W. Eillen	219 Scarlet Rd., West Toronto	Lot 7, Con. III, York	3	Sand and gravel.
"	Home Smith Estate	14 King St. E., Toronto	Lot 7, Con. III, York	2	Sand and gravel.
"	Thos. Forbear	Maple	Lot 22, Con. III, Vaughan	3	Sand and gravel.
"	Maple Sand, Gravel and Brick Co.	Maple	Lots 21, 22, 23, 24, Con. III, Vaughan	3	Sand and gravel.
"	W. Maher	846 Keele St., Toronto.	Mount Dennis	2	Sand and gravel.
"	C. Smyth	477 Runnymede Rd., Toronto	Scarlet Road, West Toronto	2	Sand and gravel.
"	York Sandstone Brick Co	Toronto	York Township	5	Sand-lime brick.
"	York Sand and Gravel Co	Toronto	York Township	8	Sand and gravel.

INSTRUCTION CLASSES FOR PROSPECTORS

By W. L. Goodwin

Introduction

Having been instructed by the Minister of Mines to organize classes for prospectors in selected centres in Ontario, the writer began on November 22nd, 1920, to make the necessary preparations, including collection and breaking up of minerals and rocks for specimens. In the basement of the Parliament Buildings were found materials which supplied about fifteen mineral species. About twenty were obtained from Queen's University through the courtesy of Professors G. J. McKay and E. L. Bruce. A few species were collected in the field and the remainder, making a set of 48 minerals and four rocks, were bought from Ward's Natural Science Establishment, Rochester, N.Y. The work of breaking up this material was so far advanced early in December that it was found possible to begin at Madoc on December 7th. After closing the class there, on December 21st, the preparation of the outfit was continued and completed by January 8th.

Methods Adopted

Classes were held in twelve places:—Madoc, Sault Ste. Marie, Port Arthur, Fort William, Sudbury, Haileybury, Swastika, Kirkland Lake, South Porcupine, Timmins, Elk Lake, and North Bay, covering the time from December 7th, 1920 to June 2nd, 1921. In each place the work consisted of two parts: a class for the determination of minerals by field tests, and a course of eight lectures on the Elements of Geology. The study of minerals was necessarily confined to daylight hours, but the lectures on geology were given in the evening. For the study of minerals, the material was distributed in small pieces to each member of the class. After determination, the occurrence, value, uses, etc., were discussed, and then printed descriptive labels were distributed, in which the specimen could be wrapped and kept for future reference. In this way it was found possible to study forty-eight minerals and several rocks, in the ten days allotted to each place. In addition to some four or five typical rocks, which were used in all the places, I found it possible, particularly in the northern gold fields, to do useful work with the rocks peculiar to the neighbourhood. The day class in each place had nine or ten sessions of about an hour and a half each.

The evening lectures were developed into a logical course on the Elements of Geology, illustrated by lantern slides, the object being to lay the foundation for more systematic study and the better understanding of reports as they are issued by the Geological Survey of Canada and the Ontario Department of Mines. These are quite generally studied by prospectors and there were frequent expressions of the helpfulness of the lectures in this connection. Eight lectures were given in each place, with the exception of North Bay, where it was thought advisable to shorten the time for both classes. It is to be noted that the evening lectures were attended by many who were not free to leave their work during the day, and by others who had a purely intellectual interest in the subject. It was felt that something was being done in this way to stimulate a more general and intelligent interest in mineral industries. To this end the lectures were always used, when possible, as a means of conveying information about the ore deposits of Ontario.

Attendance at Classes

The mineral classes were attended not only by prospectors, but by others interested in mineral industries. Some of these will become prospectors. In order to enlarge the horizon of the prospectors, a good deal of attention was paid to minerals that are not being particularly looked for. For example, samples of tin-stone were distributed everywhere. and, as soon as the material could be obtained, tinstone in the peculiar granite in which it is usually found was shown, and large specimens left in each locality, either in the Mining Recorder's office, or in some other place agreed upon.

A good deal of work was done in the indentification of minerals brought in by members of the classes. For this purpose a blowpipe set was added to the outfit. The meetings of the classes were always prolonged by work of this kind, and by consultation with the prospectors and others looking for information and advice. Where the numbers were large this made a long and busy day.

In the following tabular statement "Registration" refers to the total number attending the class for the study of minerals. Under "Average Attendance" are given numbers obtained by actual count in the case of the minerals class, and by as close an estimate as possible for the evening lectures on geology. In each place there were prospectors and others who were unable to attend the day class. Others were in the field, but had friends or partners attending the class. For such cases sets of the samples were made up when asked for. A record was kept and the numbers are given in the column "Extra Sets of Minerals." The sets of those who attended only part time were also made complete. In this way seven hundred and twenty-four complete sets of fifty-five specimens each were distributed.

Place	Date	Registration	Average Attendance		
			Minerals	Geology	Extra sets of Minerals
Madoc	Dec. 7—21	60	36	29	5
Sault Ste. Marie	Jan. 11—22	110	81	81	20
Port Arthur	Jan. 25—Feb. 4	30	23	34	15
Fort William	Feb. 7—17	38	22	60	20
Sudbury	Feb. 23—Mar. 5	21	14	49	15
Haileybury	Mar. 8—18	47	32	76	20
Swastika	Mar. 21—31	26	16	70	13
Kirkland Lake	Apr. 4—14	28	18	89	25
South Porcupine	Apr. 18—28	44	24	56	25
Timmins	Apr. 30—May 11	60	35	74	20
Elk Lake	May 14—25	30	15	73	16
North Bay	May 27—June 2	15	6	17	21
Totals		509	332	708	215

The low average attendance at the day class is to be explained by the fact that many of the prospectors did not join the class until a day or two after it was started. In some cases, too, members of the class had to break off before the end, owing to change of shift, having assessment work to do, and other causes. In some cases the news did not reach them until the class was well along. In nearly all places the class grew almost to the end. The local newspapers gave effective help by editorial notices and reports of progress as the classes went on.

Madoc

By arrangement with Reeve Burns the classes were held in the village hall. In addition to the local prospectors the classes were attended by several who came from considerable distances—one from Bancroft. By request an extra class was carried on for the Model School teachers and older students. While this extension of the work was not sought, it was not refused in any place where asked for. It will increase the interest in the study of minerals, and may help to keep up the supply of prospectors. Mr. Geo. H. Gillespie, and Mr. A. H. Watson of the *North Hastings Review*, were of great assistance in organizing the class. I wish also to thank Rev. T. H. H. Hall, and Messrs. Chris. Henderson, Donald Henderson, Wm. Cross, C. W. Wallbridge, George Lee, and Karl Stokloser for assistance in collecting minerals. The locality is particularly rich in minerals, and there are a number of keen prospectors at work there. Pyrolusite and bog manganese were brought in by members of the class and identified. Manganese ores in economic quantities are a possibility there. Through the kindness of Mr. Geo. H. Gillespie of G. H. Gillespie & Co., a large supply of talc was obtained. Mr. Robert Bryden, Manager of Canadian Industrial Minerals, sent me a box of selected fluorspar.

Sault Ste. Marie

The minerals class was held in the Board of Trade rooms, and I wish to thank the Secretary, Mr. W. E. Wolfe, for his hearty co-operation and assistance in organizing the classes. Mr. W. N. Miller, Mining Recorder, and Principal Rudlen of the High School were also very helpful. Mr. T. Taylor was engaged as assistant and his services were a considerable factor in making the work go smoothly and satisfactorily. Owing to the unexpectedly large numbers, it was found necessary to divide the day class, one section meeting at 10 a.m., and another at 2 p.m. By request a small class of graduates and advanced students of the High School was formed and I met them at 3.45 p.m. Each class was carried on for about an hour and a half. The evening lectures were held in the Carnegie Library. The very large attendance in the classes for identification of minerals introduced rather serious difficulties both in finding time for the long day's work and in eking out the supply of mineral specimens. The interest in prospecting had been stimulated by the discovery of gold near Goudreau lake, and the temporary closing down of the Algoma Steel works set free a number of prospectors working there for a grubstake, as well as many others who had made up their minds to go in for prospecting. The prospectors consulted me about a field class for the summer, asking if I or some other person could be sent by the Department of Mines to instruct such a class. I suggested that they should organize, draw up a petition, and forward it to the Minister. Forty members of the class expressed their intention of joining such a class, if it were organized. On invitation of the Rotary Club I addressed the members on the relation of the prospector to mineral industries. The Carnegie Librarian, Miss Carlyle, consulted me about books suitable for consultation and study by prospectors. Later I sent her lists supplied by W. G. Miller, and W. M. Goodwin.

Port Arthur

The city council provided quarters for the minerals class in the Ruttan building, and for the evening lectures in the council chamber, Whelan building. I engaged Mr. H. Watts as assistant. Mayor Matthews, Col. S. W. Ray, Col. Francis, J. W. Morgan (Mining Recorder), B. M. Wylie (Crown Timber Agent), and J. E. Marks gave aid and counsel in carrying on the class. I have to thank Mr. Marks for the loan of a valuable series of photographs taken in the interior of the Labrador country. Slides were made from these and used as effective illustrations in the geology lectures. Mr. F. Rodda, engineer of the Atikokan Iron Company, brought in a quantity of magnetite for use in the mineral classes, and F. Hille gave me samples of siderite and other iron ores for identification. A number of the prospectors brought in samples of molybdenite for identification. Mrs. A. S. Wink, Public Librarian of Port Arthur, wrote asking for a list of books suitable for prospectors. I sent her a list selected from those supplied by Dr. Miller and Capt. Goodwin. At the close of the classes prospectors and other citizens entertained me at lunch and invited me to speak on prospecting in relation to our mineral industries.

Fort William

Here the Board of Education provided a room for the minerals class in the Collegiate Institute and a lecture room in the fine new Technical School building adjoining. Principal E. E. Wood welcomed the classes very cordially and did much to make our work there pleasant and profitable. Mr. R. Cockburn acted as assistant. A number of keen and experienced prospectors make their headquarters in Fort William and Port Arthur. Some of those attending the classes were well acquainted with minerals. Both in Port Arthur and Fort William there is much interest in the development of an Ontario iron and steel industry using Ontario ores. Something might be done with the Atikokan and Mattawin ranges by uniting various interests and operating on a large scale. The Kiwanis Club invited me to an evening meeting to address them on our mineral industries. In connection with our iron ore resources, I ventured the opinion that we should develop processes and practice suitable to our own ores, rather than attempt to make our ores fit the established practice. Through the kindness of Dr. Oliver, Public Health Officer, I made an inspection of the Public Library, a fine building, which is used not only as a library, but as a community centre. The Librarian, Miss Black, showed me a large number of books suitable for prospectors. Very few additions are required to make a good consulting library for their purposes.

Sudbury

On the way to Port Arthur, I stopped off at Sudbury and in company with Mr. R. H. Hutchison, Principal of the Mining School there, made an examination of the possible places of meeting for the classes. It was decided that the most suitable places were those offered by the Board of Education, that is, for the day class, a room in the Mining and Technical School building, under construction, and for the evening lectures the assembly room of the High School. It was expected that the new building would be far enough advanced for this arrangement, but as the date for beginning in Sudbury was two weeks earlier than planned, I found that the room was in an unfinished state. However, the architect and contractor saw that it was made comfortable for us, and it turned out well. The building is particularly well lighted with windows, a good feature where minerals are to be examined. A number of prospectors living at Shining Tree did not see the change of date and so missed attending the class. Others had made arrangements which prevented them from coming at the earlier date. I engaged Jas. Cryderman as assistant. Some members of the class came from Copper Cliff, Shining Tree and Coniston. By request I attended a meeting of the Sudbury Branch of the Canadian Institute of Mining and Metallurgy and addressed them on the iron and steel industry. Much interest was taken in the classes by the staff of the High School, and I wish particularly to thank Mr. R. H. Hutchison of the Mining School for his assistance in organizing the class, and Mr. C. A. Campbell, Mining Recorder, for his willing and efficient help.

Haileybury

On arrival in Haileybury I had the valued assistance of the Mining Recorder, Mr. N. J. McAulay, in making arrangements for the classes. In conference with Mr. W. H. Tuke, Principal of the High School, a laboratory in the High School building was selected as the meeting place for the day class, and the assembly room was allotted to us for the evening lectures. Both were found very convenient and comfortable. Thanks are due Principal Tuke, Mr. James Hill of the Mining Department of the school, and other members of the staff. Here, as in some other places, the prospectors were a little slow in gathering, but finally they fairly crowded the small laboratory, many coming from Cobalt and New Liskeard and one from as far away as St. Thomas. The great majority of the class were experienced prospectors with considerable knowledge of minerals and rocks. In conversation with some of them I found that they had been studying text books like those of LeConte and Kemp. Mr. L. E. Hamilton, a student of the Mining School, assisted in the work of the classes. At the close of the Haileybury classes, it was arranged by correspondence with the deputy Minister of Mines that Mr. Hamilton should act as assistant to the end of the campaign. This arrangement worked out well, and Mr. Hamilton was thoroughly satisfactory.

At the close of the classes a Prospectors' Association was organized with Mr. James Hill of the Mining School as President, Mr. Train as Secretary-Treasurer, and Dr. W. L. Goodwin as Honorary President. At a banquet held a day or two later at which about eighty prospectors and mining men were present, the organization of the Temiskaming Prospectors' Association was completed, and the whole subject of prospecting in relation to mineral industries was thoroughly discussed. This discussion was made more valuable by the presence of a number of mine managers who could give the point of view of the investor. It would doubtless encourage prospecting and lead to more rapid development if there were some better connecting link between the prospector and the investor. Too often the prospector finds himself unable to continue in his chosen calling because he has reached the end of his means and has been unable to make a sale of claims. It is quite likely that further development of some such claims would show valuable results. What seems to be needed is some more systematic provision for development. Some better plan than the present rather haphazard way might be worked out by frank discussion at joint meetings of prospectors' associations with the Mine Managers' Association and similar bodies.

Swastika

This place was chosen on the request of a Prospectors' Association which has its headquarters there. We were met at the station by Mr. H. Geo. Ginn, Mining Recorder. Mr. T. M. Boisvert, President, and Mr. C. Billington. Secretary of the Prospectors' Association. Prospectors and others gathered in the evening in a room over Boisvert's store and I addressed them there. It had been the intention to start the class that afternoon, but as the train was several hours late, that was found impossible. A good start was made next day, the day class over Boisvert's store, and the evening lectures in the Union Church. Thanks are due Mr. T. M. Boisvert for the use of his room, to Messrs. Billington, Boisvert and others for assistance in fitting up the room and moving the apparatus from the station, to the Board of Management of the Union Church for the use of the church, to Rev. Jas. Lyttle for many kindnesses, including the use of his lantern, to the club of the local school for the use of their lantern, to Mr. T. A. McArthur, Inspector of Recorder's Offices, whose room in Swastika I occupied while there, to Mr. Ginn for the use of his office and for attending to the advertising, and to many friends for their unremitting efforts to make the class a success and our stay a pleasant one.

In this place as in others the number of men who have a good knowledge of minerals is noteworthy. This class was remarkable in having as one of its members, Miss Fetterly, an experienced practical prospector. On the evening of the last day in Swastika, we were very pleasantly entertained at a social gathering held in the Union Church.

Kirkland Lake

By arrangement with Mr. John Gillan the day class was held in the Miners' Union Hall, and it proved to be a comfortable and commodious classroom. The evening lectures were given in the Union Church (Rev. Jas. Lyttle, Pastor). To the officials of both Labor Union and Church, I wish to tender my best thanks. The day class here was attended by many experienced prospectors, including Miss Gertrude Oakes. Kirkland Lake is an unusually compact mining camp, which made it possible for the officials of a number of the mines to gather at the evening lectures. This made it very interesting for the lecturer, who wishes to embody in this report his appreciation of the compliment thus paid him and also of their warm hospitality. Mr. R. C. Coffey, Manager of the Lake Shore Mine, helped me collect samples of porphyry and lamprophyre and gave me a large specimen of telluride. This material was used at all the remaining places visited. Mr. Porteous, manager of the Hunton-Kirkland mine, gave me specimens of wolframite which were useful in the other places visited. A significant incident of our stay here was a visit from a Shining Tree prospector who wished to get information about the rocks and minerals characteristic of the Kirkland Lake area. He spent several days with us, and took with him a complete set of the mineral and rock specimens.

South Porcupine

On arrival at South Porcupine we were met by Mr. W. A. Donaghue, Mining Recorder, who had made all arrangements for hotel, place of meeting, etc. The classes were held in the Oddfellows' Hall, which proved quite satisfactory for the purpose. We made a visit to the Dome Mines, where we were pleasantly received by the General Manager, Mr. Depencier, who, with the Superintendent, Mr. Dowsett, showed us over the surface features, mill, etc. I have to thank Mr. C. E. Morgan for assistance in collecting mineral and rocks. We got supplies of greenstone, diabase, ankerite, quartz, porphyry and tourmaline (near Clifton mine). Mr. Offer, manager of the Clifton, gave us a considerable quantity of scheelite which occurs there. In organising the classes I had much assistance from Messrs. Donaghue, W. G. A. Wood (Crown Timber Agent) and Morgan. Here, as in other places, it was noticed that many of the prospectors were acquainted with a considerable range of minerals. Men attended from Dome Mines, Schumacher, and Pottsville. At a Board of Trade banquet held after the classes were closed, I was invited to speak on "Our Mineral Industries."

Timmins

By arrangement with Mayor McInnis and Councillor Longmore, the O.B.U. hall was secured for the day classes, and the Miners' Union hall for the evening lectures. The officials of the Unions gave us their hearty co-operation and assistance in preparing the halls for the work of the classes. The Timmins class was notable for the large number of active prospectors, some of whom came from considerable distances, two from Hearst. The hour for the day class was set to suit one of the mine shifts, as a considerable number of prospectors were working in the mines. Two prospectors told me of finding a large piece of float which corresponded with tin-stone samples distributed to the class. Afterwards they sent in samples which were tested and found to be tin-stone. By invitation we visited the Porcupine-Crown, Hollinger and McIntyre mines, and have to thank managers Stewart and Ennis, Mr. Webb, Manager of the Hollinger stores, and engineers Bell, Robinson and Longmore for making these visits pleasant and interesting. We collected supplies of quartz-porphyry and feldspar-porphyry. In all the classes held in the gold areas great stress was laid on porphyries by careful examination of specimens by the class, by definitions, and by microphotographs shown in the evening lectures. As porphyries are associated with the ore bodies in all our new gold fields, it was thought important for the prospectors to have clear ideas on that subject.

Elk Lake

The Council had selected as meeting places for the classes the council chambers for the day class and the school house for the evening lectures. Mr. M. R. Morgan, Mining Recorder, helped us make preparations for the classes and was kind enough to allow me the use of his office for writing letters, etc. I have also to thank Col. H. E. McKee, and Messrs. D. J. Giles, McKinley, and A. P. Campbell for assistance in collecting supplies of minerals and rocks from the Beaver, Silver Alliance, and Blight properties. Bornite, malachite, micaceous hematite, diabase, gabbro, and epidote were obtained. Mr. Frank Wescott gave me some pieces of very pure "kidney" hematite from his new discovery in Montrose? township. Many prospectors were noted on their way up the Montreal river to the Matachewan region. Large numbers were also going into Bruce township, and some claims were staked for gold in Midlothian township.

North Bay

Most of the prospectors who formerly made North Bay their headquarters have moved out, probably gone farther north. But it was thought worth while holding a class there as an experiment. While the attendance was small, the result in increasing the interest in exploration for minerals, was encouraging. Special stress was laid on the advisability of prospecting for minerals other than gold and silver, particularly those that might occur in granite and gneiss. By arrangement with Mayor Ferguson, the classes were held in the fine Normal School building, where Principal Casselman and his staff gave us every facility and made us very much at home. I have also to thank Messrs. Barry Shephard, G. Galvin, and C. G. Watson for many kindnesses, and much help.

General

If the many expressions of appreciation are taken as a fair indication of the value of this work, there can be no doubt about the advisability of continuing and elaborating it. The old days of prospecting by pure chance methods are passed. The prospector of to-day studies the geological maps and reports, and uses them intelligently. He is eager to enlarge his acquaintance with mineral species and rock formations, and to improve his methods by making them more scientific. Prospecting is becoming more and more a profession, in which, however, there will always be room for those of various degrees of scientific education. Advance in mineral industries depends primarily upon the prospector. If he stops work, there is no more progress. This only needs to be stated, and it at once follows that the profession of prospecting should be carefully nurtured, first by providing adequate facilities for education and second by such economic practice as will ensure a fair return to the prospector—a living wage. He invests his time, money and skill as the pioneer adventurer in mineral development.

Suggestions

At the present stage it does not seem possible to use the ordinary systems of education to meet the case of the prospector. In some way he should get the elements of chemistry and physics—just the essential ideas of these subjects, without the elaboration and detail of the ordinary textbook. This would be the foundation for the study of minerals and rocks, and the essentials of geology and ore deposits. All this can be done in winter, when prospecting is mostly held up. By means of summer field classes the prospector could be instructed in field geology, note-keeping and sketching. This should be done by instructors who are field geologists with some experience in prospecting. A great deal can be accomplished even in a few days of such instruction. The prospector needs only a start. He can be trusted to go on by himself. There are certain facilities for self-education which may be usefully provided. In a number of places where classes were held, the public librarian has adopted the idea of a prospectors' corner or section, where books and reports will be found specially interesting to prospectors. This movement should be encouraged, so that in every centre where prospectors make their headquarters they may count on finding the right books, maps, etc. In such places mineral and rock collections may be placed. These should be rather different from the ordinary collections—they should be particular and not general—illustrative of the rocks and minerals of the district. Special collections of gossans, stains, and other "signs," and minerals with their associated rocks, should be made, with the minerals they indicate—all so placed and described in large print that the student may be able to readily take in their meaning. Occasional illustrated lectures by members of the Department of Mines staff and others might be given in such places on subjects of current interest, for example on new discoveries of economic importance.

While it seems hardly possible to utilize the ordinary educational facilities, the mining schools in such places as Sudbury and Haileybury might be used in several ways. The collections mentioned could be housed there, the prospectors' classes and lectures might as a matter of course be held in the same place, and the teacher of geology in the mining school might be engaged to instruct field classes in the summer.

This is hardly the place to discuss the immediate return the prospector should get for his work. It is a very difficult subject, but those most interested should address themselves to it. The present conditions are hardly satisfactory. Many of the best prospectors are becoming discouraged. There is a good deal of chance in the business, and some scheme should be devised for carrying over those whose lucky strike is slow in coming.

Investment in prospecting is subject to the same uncertainties as are found in other business. The credit system is used in the latter and as the business goes on a living is taken out of it. The same idea applied to the independent prospector should in some way give him his living and enable him to go on until he made his strike.

In conclusion it is suggested that the places for holding classes should be selected at an early date so that the whole list with dates of beginning may be published in newspapers. This will enable the prospectors to arrange their business so as to reach the selected place in time.

Notes on Clays of the Missinaibi River[1]

By

Joseph Keele

Introduction

In a former report[2] certain clay deposits on the Mattagami river were called "Swamp Clays" as they were different from any of the late or post-glacial clays in the region. From the evidence obtained on the Missinaibi river the writer has no hesitation in assigning the so-called swamp clays on the Abitibi and Mattagami rivers to an interglacial age. The interglacial clays seen on these rivers were only very small remnants and at no place was the overlying late glacial boulder clay present, so that their true relation to the rest of the drift was not in evidence and hence the doubt as to their origin; but there is no doubt whatever about the interglacial age of similar materials on the Missinaibi river.

The yellowish sands and gravels included in the interglacial series have no economic value as they are subject to the same defects as all glacial sands, that is they are mixed with rock particles and glacial dirt of various kinds. These sands are not to be confused with those called yellow, orange and reddish sands described in the 1920 report.

Mesozoic Clays

Mesozoic clays and sands of Lower Cretaceous age were formerly widespread in northern Ontario, but a long period of pre-glacial erosion and two distinct glaciations in Pleistocene times have well nigh obliterated them, and now only small detached patches are found wherever the rivers have cut down through the overlying glacial debris deeply enough to expose them. The Mesozoic clay and sands on the Mattagami river were described in the report for the year 1920, but a much larger remnant than any of these occurs on the Missinaibi river. It is situated on the east bank of the river about 4 miles above the mouth of the Wabiskagami, and there is an outcrop of similar clays on the latter river which may be the continuation of the beds on the Missinaibi, as the outcrops are only two miles apart. These deposits are 45 miles north of the Canadian National railway line. The Cretaceous beds are exposed for a distance of half a mile along the bottom of the bank that in places rises to a height of 30 feet above the river. The greater part of the deposit is sand, mostly white, but stained in places to a pink and yellow colour, and a small quantity of white clay is mixed with the sand. The clay is of various colours, white, pink and yellow, but beds of mottled pink and white clay make up the bulk of the clay beds. The whole deposit is overlain by the late glacial stony clay, and some of this clay is pressed in and mixed with the Cretaceous clay for a depth of several feet. Two small streams which cut through the overlying glacial drift expose the lower clay and form convenient places for examining the deposit. The overburden of glacial clay is so thick that except on the immediate river bank it would be difficult to remove it for the economic working of the lower clay. The value of the deposit as a whole depends on the mottled clay and quartz sand. The mottled clay is a No. 3 fire clay and the sand would be suitable when washed for the manufacture of glass.[1]

---

[1] This short paper is a continuation of the report, under the same title and by the same author, which appeared in Volume XXX, 1921, Part I, pp. 171-175.

[2] Ont. Dept. Mines, Vol. XXIX, 1920, Part II.

A deposit of Cretaceous clay similar to the above was examined in 1899 by E. B. Borron, stipendiary magistrate, and the results were published in his report[2] to the Attorney-General of Ontario. The deposit was on the bank of Coal creek, a small stream entering the Missinaibi about 5 miles above the Wabiskagami river. Mr. Borron bored several holes in the clay and found 35 feet in thickness of black, pink, white and mottled clays and a bed of lignite—the whole underlain by a thick bed of white sand. This section is almost identical with the one found on the Mattagami river. This deposit was looked for by the writer but he was unable to find it. It appeared that the overlying clay had fallen and covered the exposures of Cretaceous clay and displaced the brook. Poplar trees nearly a foot in diameter are now growing on the former site of the outcrops.

---

[1] The results of the physical tests and chemical analysis of the clays and sand is given in the Summary Report of the Mines Branch, Dept. of Mines, Ottawa, 1920.

[2] Basin of the Moose River, published by Warwick & Sons, Toronto, 1890.

END OF PART X.

INDEX

Vol. XXXI, Part X

PAGE

A

Abitibi river, clay 95
Accidents, report on 1-10
Acres limestone quarry 71
Acton, C. J. 14, 66
Acton, J. U. 66
Acton Mines, Ltd. 14, 66
Adair, John 45
Addington co. *See* Lennox and Addington.
Agnew, John L. 24, 25
Agnew, N. J. 4, 14
Aikens, Berton A. 21
Alabastine Company of Paris 76
Aladdin Cobalt Co. 14, 44, 47
Albion tp., brick plant 78
Aldborough tp., gravel pit 82
Aldershot, brick plant 79
Alfred tp., limestone 75
Algoma Steel Corp. 4, 13, 21, 67
Algomont Mines, Ltd. 11, 22
Alini, W. 4
Allen, S. H. 12, 31
Allen Bros. 86
Allgeier, F. C. 25
Alpine Silver Mines, Ltd. 14, 57
Amabel tp., limestone 71
Amber mica. *See* Mica.
American Cyanamid Co. 75
American Molybdenite, Ltd. .. 14, 66, 67
Ames, G. C. 51
Analysis.
  Feldspar, Storrington tp. 62
Ancaster Hill 76
Anderdon tp., limestone 72
Anderson, A. J. 13, 22
Anderson, A. K. 12, 47
Anglo-American Talc Corp. 67
Angus, D. H. 12, 40
Argonaut Gold, Ltd. 12, 29
Armstrong, James A. 23
Armstrong Supply Co. 85
Artemesia tp.
  Brick plant 78
  Gravel and sand 83
Asam copper m. 22, 23
Asbestos Pulp Co. 15, 67
Ashley, James L. 24, 25
Ashley, L. 67
Asquith tp., gold mg. 45
Associated Goldfields Mg. Co. *See* Canadian Associated Goldfields.
Atikokan iron mine 13, 17
Atlas Brick Co. 78
Attalah, M. A. 12, 47
Auer, C. M. 39
Augusta tp., limestone 72
Austin, E. T. 27

PAGE

Averill, Chas. S. 39
Axford, Jos. 82

B

Babcock feldspar claim 59
Bache, J. S. 31
Baden tp., gold mg. 45
Badger, Harry S. 13
Bailey Silver Mines, Ltd. 14, 15, 47
Baird, F. B. 68
Baker, D. 30
Baker, G. Vaughan 63
Ball, S. 4
Bannerman, Geo. 78
Baptiste Lake, dolomite mine ... 11, 58
Bapty, F. A. 68
Barrie, gravel 85
Barry Construction Co. 75
Bartlett, James 1, 11
Barton, W. E. T. 14, 67
Barton tp.
  Brick plant 79
  Limestone quarries 76, 78
Bartonville 86
Bartonville Pressed Brick Co. 79
Bass l. 69
  See also Kirk g.m.
Bateman, G. C. 14, 15, 47, 50
Bathurst tp.
  Feldspar mg. 60, 61
  Sand pits 83
Beachville, lime kilns 75
Beachville White Lime Co. 75
Beard, James W. 25
Beatty tp.
  Gold mg. *See* Majestic Gold Mines, Ltd.
Beaumont Gold Mines, Ltd. 12, 31
Beckwith tp. granite quarry 73
Bedford tp. feldspar quarry 59-61
Bell, J. B. 14, 65
Bell, James H. 21, 67
Bell, J. Macintosh 14, 56
Bell, Thos. E. 4
Bellyou, N. E. 84
Belmont tp., trap quarrying 75
Bennet, Joseph 86
Benson and Patterson 85
Benton, James 60, 62
Bergin, Patrick 74
Bergonan, Paul 85
Bertie tp., limestone quarries 76
Beverley tp., limestone quarries 77
Bewick, Moreing & Co. 33
Bidgood Gold Mines, Ltd. 12, 40
Big Dyke Gold Mines, Ltd. 12, 31
Billings Bridge, brick plant 78
Billington, C. 91

PAGE
Birkett, E. H. 12, 21
Bishop, A. L. 48, 68
Bishop silver m. 58
Bishopsgate 80
Black, John 23
Black, John H. 39, 52
Black Donald graphite m. 13, 64
Blackwell, Walter 23
Blain, James E. 82
Blake, Charles E. 16
Blake, George J. 16
Blanche Bay Syndicate 12, 30
Blast furnaces. *See* Metallurgical works.
Blizard, Edison 84
Blood, Sir Bindon 44
Blue Quartz Gold Mines, Ltd. 12
Boehm, M. S. & Co. 86
Boisvert, T. M. 91
Bolingbroke 66
Bolton, A. J. 41, 42
Bonanza gold m. 12, 15
Bonnell, H. 64
Bonnin, Florence M. 28
Bonsall Mines, Ltd. 57
Book J. H. 74
Booth J. Fred. 24
Borden, Sir. Robt. 24
Borresen, Sir U. J. R. 24
Bousquet Gold Mines, Ltd. 12, 46
Bowzan, M. L. 13, 31
Bowman, D. J. 85
Bradley, J. W. 74
Braniff, Harry 42
Brant co.
  Gravel pits 80
  Tile and brick plant 78
Brant tps.
  Gravel and sand 81
  Limestone quarry 71
Brantford.
  Brick plant 78
  Gravel and sand 80
Brantford Sand and Gravel Co. 80
Brebner feldspar quarry 59
Brick and tile 78, 79
Bridgeport, gravel and sand 85
Brigham, A. F. 12, 34
British American Nickel Corp. .. 14, 24
Britnell & Co. 75
Britton, Arthur H. 33
Broadwell & Son 78
Brockville 74
Brown, Alex. C. 74
Brown, J. V. 60
Brown, Robert 74
Brown, S. M. 24
Brown, W. 84
Browne, K. C. 26
Brownlee gravel pit 81
Brownson, Willard H. 25
Brougham tp., graphite 64
Brouse, W. H. 52
Bruce, E. L. 87
Bruce co.
  Gravel pits 80, 81
  Limestone quarries 71
  Tile and brick plants 78

PAGE
Bruce nickel m. 14
Bruce tp.
  Brick plants 78
  Gold prospecting 93
  Gravel pit 80
Bruce Mines, Ltd. 27
Bryden, Robt. 89
Buffalo silver m. 4
Builders Supply Co. 84
Bull, George A. 21
Bullion gold m. 17
Bunting, R. F. 13, 64
Bupon, G. H. 74
Burford tp., gravel pit 80
Burke gold claims 12, 45
Burkell, R. B. 21
Burlington Heights.
  Gravel and sand 85
Burnip, F. W. 58
Burns, Mr. 89
Burns feldspar claim 61
Burns gold claims 39
Burnside gold m. 44
Burrows, J. T. 80
Burt, A. 44
Burton, Archie, S. 45
Bush, A. T. 67
Butchart, David 25
Byng, Dunn tp. 73
Byrne, J. J. 14

C

Cabana, Oliver 44
Cables, testing of 9
Caesar, Charles 27
Cain, Harry J. 14, 61, 66
Calcite 11, 59
Caldwell, Thos. B. 11, 59
Caledonia, gypsum 13, 64
Callinan, J. W. 39
Callinan-McKay Exploration Co. 39
Cambridge tp., limestone 75
Camden tp.
  Brick plant 78
  Limestone quarry 74
Cameron, Donald A. 59
Campbell, C. A. 90
Campbell, C. L. 17
Campbell & Lattimore 74
Campbellford, gravel pit 84
Campoli, L. 4
Canada Cement Co. 76
Canada Crushed Stone Corp. 76
Canada Lime Co. 75
Canadian Associated Goldfields, Ltd. 12, 29
Canadian Construction Co. 76
Canadian Furnace Co. 15, 67
Canadian Pressed Brick Co. 79
Cane tp., silver mg. 57
Cane Silver Mines, Ltd. 57
Carleton co.
  Brick plant 78
  Gravel and sand 81
  Limestone quarries 71, 72
Carlyle, E. J. 24

PAGE
Carmichael, A. 14, 28
Carrol Bros. 85
Carson, John J. 83
Carss, William 82
Cartwright gold m. 12
Cartwright Gold Fields, Ltd. 30
Cascadden, C. A. 82
Case, Whitney G. 64
Castle silver mine 58
Castle Mining Co. 58
Castle-Trethewey Mines, Ltd. 58
Cavanagh gold claim 39
Cavers, T. Willard 24
Cement.
  Limestone for 73, 75
Chambers-Ferland silver m. 14, 47
Chapman, John 78
Cheyne, James C. 28
Chinguacousy tp., brick plant 78
Chirico, Angelo 45
Chisholm Wellage Co. 74
Christopher, A. G. 55
Church's gravel pit 80
Cimetta, R. 4
City View limestone quarry 71
Clancy, R. 80
Clarence tp., limestone 75
Clark, E. B. 59
Clark, G. M. C. 51
Clarke, K. S. 27
Clarke, William D. 28
Classes. *See* Instruction classes.
Clay.
  Accidents in working 1-8
  Missinaibi r. 95, 96
Clemson, Dan 28
Clinton tp., limestone 74
Clobridge, Charles 62
Clobridge feldspar mine 11
Close, James V. 83
Cobalt, Bass l. 69
Cobalt A-53 silver mine 14, 48
Colbalt Frontenac Mining Co. 12, 63
Cobalt Reduction Co. 51
Cobalt silver area.
  Mining reports 47-55
Coboconk, limestone quarrying .. 75, 76
Cochenour, William M. 30
Cochrane gold claims 45
Cockburn, R. 90
Coffey, R. C. 12, 41, 92
Cohen, Maurice 46
Coldwater 79
Coldwater Brick & Tile Co. 79
Cole, G. E. 1, 11
Coleman tp.
  See Cobalt silver area; Hyland silver m.
Collier, A. H. 56
Collier, H. H. 48
Collins, Charles 26
Collins, F. Howard 14, 57
Collins, Thomas R. 80
Collins silver mine 14, 57
Concrete products.
  List of producers 71, 84-86
Coniagas Alkali and Reduction Co. .. 68
Coniagas Mines, Ltd. 4, 14, 48, 68
Coniagas Reduction Co. 15, 68
Coniston nickel-copper smelter 27
Coniston quartzite quarry 27
Conkey, M. J. 45
Connolly talc mine 15, 67
Contact Bay Mines, Ltd. 12, 15
Coon, Dr. D. A. 62
Coon, H. A. 62
Cooper, Fred. 41
Cooper, W. H. 79
Cope, Francis E. 23
Copper.
  See Algoman Mines Ltd.; Jewel Gold & Copper Mg. Co.
Copper Cliff.
  Nickel. *See* International Nickel Co.
  Smelter 26
Corey, W. E. 25
Corkill, E. T. 25
Corless, C. V. 27
Corning, Fred. G. 31
Corundum 11, 59
Corundum, Ltd. 11, 59
Costello gold mine 12, 29
Cottrill, Charles W. 80
Couch, Walter B. 12, 63
Cowan, C. A. 68
Cowan Bros. 85
Cowie, Geo. S. 22
Craig, Ernest 40
Craig, George R. 26
Craigmont 11
Crain, James 59
Crawford Bros., brick works 85
Crawford gravel pit 81
Creighton nickel mine 4, 14, 25, 26
Cromwell, William N. 25
Crosby, A. B. 40
Crow, H. C. 30
Crow, J. E. 85
Crown Reserve Mg. Co. 12, 30
Crumble, J. A. 49
Crushed Stone, Ltd. 76
Cryderman, Jas. 90
Crystalline limestone.
  Details of quarries 73, 75
Culford, W. J. 4
Culross tp., brick plant 78
Culver, F. L. 40
Currie tp., waterpower 30
Curry, Daniel 41
Curry, N. 41
Curry, R. 41
Curtis Bros. 79
Czarina Gold Mines Co. 15

D

Daeschner, Wm. J. 20
Dagenais, J. 82
Daimpré, C. G. 12
Dale, James 67
Dalton, William H. 39
Danforth, Frank L. 28
Danhof, John J. 21
Davidson, G. M. A. 40
Davidson gold mine 13

PAGE
Davidson Consolidated Mines, Ltd. .. 38
Davies, O. 21
Davis, J. J. 38
Day, James E. 46
De Blois, W. H. 14, 65
Deloro Mining and Smelting Co. 4, 15, 68
Dempster, Thos. 49
Denison, Chas. L. 42
Denker, C. T. 13, 40
Dennis tp., limestone 72
Denny, James J. 52
Denyes, Horace G. 84
De Pencier, H. R. 12, 31, 92
Derby tp., gravel and sand 83
Deroche tp.
  Iron mining 22
  Quartzite 71
De Rosa, Savario 45
Deschênes, Que. 24
Despard, W. H. 59
Dethloff, W. L. 27
Detroit Goudreau Gold Development Co. 12, 20
Dewar, James S. 14, 80
Dickenson, J. G. 54, 57
Dickson Creek (Cobalt) Silver Mines, Ltd. 14, 49
Dill quartz quarry 26
Dobson, Mrs. Thos. 80
Dochart Brick, Tile & Terracotta Wk. 79
Dodwell, Mr. 66
Dodworth, James R. 39
Dolomite 11, 58
Dome Extension gold mine 32, 33
Dome Mines Co. 12
  Accident at mine 4
  Mining report 31-33
Dominion Mines & Quarries, Ltd. 14, 55
Dominion Sewer Pipe & Clay Industries, Ltd. 79
Donaghue, W. A. 92
Donaldson, Oliver G. 44
Donaldson, S. 4
Donaldson, W. J. 82
Don Valley Brick Co. 79
Dore, Albert 4
Dorr, John 76
Downey tp., gravel and sand 84
Dowsett, C. W. 31, 92
Drummond tp., sand pits 83
Dufferin Construction Co. 76
Duffy, Charles G. 44
Duguette, Wilfred 29
Dumfries tps., gravel and sand .. 80, 85
Dunbar, P. W. 69
Dundas, limestone 76
Dundas co., stone quarrying .. 72, 81, 82
Dungannon tp.
  Marble quarry 73
Dunlap, David A. 34
Dunn tp., limestone quarry 72, 73
Dunwich tp., gravel and sand 82
Duoro tp., brick plant 79
Duval, Joseph C. 60
Dwyer, R. J. 67
Dycie, J. G. 28
Dye, Norman E. 14, 57
Dye, R. E. 14, 47
Dyment, Noah 63

E

Eager, Frank J. 14, 27
Eagle l., Hinchinbrooke tp. 66
Eagle l., Manitou L. dist. 16
Earle, E. R. 52
Eastern Ontario, mining reports . 58, 86
Echo Place 89
Edwards, Gordon C. 59
Edwards, W. S. 31
Edwardsburg tp., limestone 72
Egan tp., gold mining 30
Eganville, limestone 75
Eldon tp., limestone 76
Electro Bleaching Gas Co. 68
Elgin co., gravel and sand 82
Elizabethtown tp., road material 74
Elk Lake, classes for prospectors 87, 88, 93
Elk Lake mg. dist., mining reports 57, 58
Ellice tp., gravel and sand 84
Elliott, R. A. 68
Elmsley tps., sandstone 73
Emens, W. H. 14, 54
Emery feldspar claim 11, 59
Emmons, Harold D. 16
Empey, W. F. 41
Empire Limestone Co. 85
Empress gold mine 15
Empress Gold Mg. Co. 16
Ennis, R. J. 13, 93
Erion, Edward R. 60
Erleigh, Viscount 27
Ernestown tp.
  Gravel and sand 84
  Limestone 74
Errington, Joseph 37
Escott tp., paving stones 74
Esquesing tp.
  Brick plant 78
  Limestone 73
Essex co.
  Brick plants 78
  Gravel and sand 82
  Limestone 72
Eureka Flint and Spar Co. 11, 59
Euxenite 61
Evans, D. Owen 27
Evans, R. E. 38
Evans, W. Arthur 46
Evered, N. J. 13
Explosive accidents 2-9

F

Fairlie, M. F. 14, 51
Faraday tp., limestone quarry 73
Fasken, Alex 31, 52
Fasken, David 52
Fatalities. *See* Accidents.
Faulkner, J. E. 82
Fawcett tp., gold mg. 45
Featherston, Thomas 82
Federal Feldspar, Ltd. 59
Federal Mining Co. 14, 18

PAGE

Feldspar.
  Mines, list of 11, 12
  Mining reports 59-63
Feldspar, Limited 11, 59
Feldspar Quarries, Ltd. 59
Fennell, Robert 38
Fergus, limestone 76
Ferguson, Harcourt 44
Ferry's limestone quarry 77
Felterly, Miss 92
Filmer, Arthur Wilson 38
Finch tp., limestone 75
Finucane, T. R. 31
Fitzroy tp., gravel and sand 81
Flamborough tp., limestone 77
Flavelle, William 67
Fletcher, A. E. 13
Fletcher, D. H. 12, 63
Fletcher, Jos. H. 85
Fletcher, M. E. 63
Fluorite 12, 63
Flux, limestone for 76
  quartz for. *See* Dill,
  quartzite for 27
Flynn, J. R. 18
Folger estate 66
Folger mica mine 14
Fonthill Sand and Gravel Co. 85
Forbear, Thos. 86
Forbes, D. L. H. 13, 42
Forbusch, Frank 39
Forest, W. L. 45
Forrester, Geo. 82
Fort William.
  Classes for prospectors at 87-90
Forwell, J. K. 85
Foster, Clement A. 20
Foster silver mine 51
Fourteen Island lake 62
Fox, Geo. J. 78
Fox, J. 78
Francis, Col. 89
Francoeur limestone quarry 75
Franz, W. C. 21
Fredericksburgh tps.
  Brick plant 78
  Limestone 74
Frid Bros. 85
Frontenac co.
  Gravel and sand 83
  Limestone quarries 72
  See also Bedford tp.
    Loughborough tp.
    Pittsburgh tp.
    Storrington tp.
Frontenac lead mine 14, 65
Frontier silver m. 14, 51
  See also Haileybury Frontier.
Fulton, S. 82

G

Galbraith tp., gold mg. 21
Galetta, lead mg. 65
Gallagher, Ziba 23
Gallagher Lime & Stone Co. 76
Galt, limestone quarry 76
  gravel and stone 85

PAGE

Galvin, G. 93
Gamble & Co., Feed 75
Ganonoque, road material 74
Gardner Feldspar Co. 11, 59
Garson nickel m. 14, 27
Gauthier, H. G. 39
Gauthier tp.
  Gold. *See* Argonaut Gold, Ltd.
Geissler, G. Cosby 20
Gelinas, A. 67
Gentles, Charles A. 45
Giaya, Italis 45
Gibson, Jas. 83
Giersten S. 24
Gilchrist & Co. 67
Gillan, John 92
Gillespie, Mrs Elizabeth 83
Gillespie, Everett 26
Gillespie, Geo. H. 15, 67, 89
Gillespie & Co., Geo. H. 15, 67
Gillies limit.
  Silver mining 48
    See also Oxford Cobalt.
Ginn, H. Geo. 91
Giroux L., silver mg. 47
    See also Oxford Cobalt.
Glascow & Mulligan 79
Glendinning, George 16
Glendinning, L. 4
Glendower 59
Globe, A. R. 39
Gloucester tp.
  Brick plant 78
  Gravel pits 81
  Limestone quarries 72
Gneiss quarries 74, 75
Godfrey & Son, T. 78
Gold.
  Mining accidents 1-9
  Mining reports 15, 20, 21, 63, 64
Gold island, Night Hawk l. 39
Goldale Mines, Ltd. 33, 50
Golden Fleece gold m. 63
Golden Summit Mg. Co. 30
Goluk, H. 4
Goodchild, W. H. 47
Goodwin, W. L.
  Report on Instruction Classes 87-94
Gordon, M. B. R. 11, 60
Gordon, R. 74
Gordon, W. A. 42
Gosfield tp.
  Brick plant 78
  Gravel and sand 82
Goudreau 28
Goudreau Gold Mines, Ltd. 20
Goudreau Superior Mg. Co. 21
Goulais r., iron mg. 13, 21
Goulburn gravel pit 81
Gould, Arthur
Gow, Jas. A. 76
Gower tps., gravel 81
Gowganda l. 57
Gowganda mg. dist.
  Mining reports 57, 58
Grace gold m., Eagle l. 16
Grace gold m., near Wawa l. 21
Graham, R. 40

PAGE

Graham, William T. 25
Grand r., limestone 76
Granite l., Fawcett tp. 45
Granite quarries 72, 74
Grant Bros. 75
Grantham, gravel pit 80
Grantham tp., limestone 74
Graphite.
  Brougham tp. 13, 64
  Silver islet 18
Gravel. *See* Sand and Gravel.
Gravenhurst Crushed Granite Co. 74
Gray, Charles N. 16
Gray, J. J. 67
Greco, Peter 47
Greene, Richard T. 52
Greenock tp., gravel 80
Grenet, Sam J. 39
Grenfell tp.
  Gold mg. *See* Blanche Bay Syn.
Grenville co., limestone 72
Grey Co.
  Brick plant 78
  Gravel and sand 83
  Limestone 72
Grierson, A. W. 40
Griffith, Sir E. J. 27
Grigg, John 27
Grimsby tp., limestone 74
Griswold, Norman 82
Gronningsaeter, A. 24
Gros Cap Mining & Exploration Co. 28
Gross, David 422
Grover, George 39
Grzybowski, Stanley 17
Guelph tp., limestone 76
Gull l., Lebel tp. 40, 42
Guntrip, H. J. 44
Guy, George J. 17
Gypsum 13, 64

H

Hadfield, Sir Robert 27
Haggerty, Richard 30
Haileybury.
  Instruction classes for prospectors 87, 88, 91
Haileybury Frontier silver m. 55
Haire, Robt E. 64
Haldenby, Charles N. 23
Haldimand co.
  Limestone quarries 72, 73
Hale, J. M. 82
Hall, Oliver 27
Hall, Rev. T. H. H. 89
Hallis, Sam 39
Hallowell tp.
  Gravel and sand 84
  Limestone 75
Halton co.
  Brick plant 78
  Limestone 73
Halton Brick Co. 78
Hamblin, W. H. 42
Hambly, George T. 40
Hambro, Sir Erie 24
Hamilton, L. E. 91

PAGE

Hamilton.
  Blast furnace 15, 69
  Brick plant 79
  Gravel and sand 85
Hamilton Pressed Brick Co. 79
Hamilton Sand and Gravel, Ltd. 85
Hammond, A. 83
Hands, Wm. J. 23
Hargrave silver m. 50
Harker tp., gold mg. 30
Harkness, James 55
Harris, J. G. 27
Harris, L. C. 31
Harris-Maxwell gold property 29
Harrison, Major D. B. 39
Hart, R. J. 48
Harvey & Son, E. 71
Harwich tp., gravel and sand 83
Hasselbring, Albrecht 62
Hastings co.
  Brick plant 78
  Limestone 73
Hattin, V. H. 42
Havilah gold mine 21
Hawkesbury tps.
  Brick plant 79
  Limestone quarry 75
Hawson, James 21
Hayden, Charles 25
Hayden, W. H. 12, 33
Hayden Gold Mines, Ltd. 12, 33
Hearst, W. I. 20
Heckscher, August 52
Henderson, Chris. 89
Henderson, Donald 89
Henderson & Co., Christie 76
Henderson granite quarry 74
Henderson talc mine 15, 67
Henley, E. S. 15
Hennessey, A. W. 48
Herbold, Albert 69
Hermo Mining Co. 54
Herschel tp., dolomite 58
Hetherington, F. E. 55
Hibbert, Ernest 24
Hickling, John F. 69
Hicks, T. M. 68
Higgins, G. J. 68
Higginson, Geo. & Son 75
Highways, Dept of
  Gravel quarrying 80, 83
  Stone quarrying 4, 74-77
Hlidreth, Andrew G. 39
Hill, James 91
Hill, Netter J. 21
Hille, F. 90
Hillier tp., limestone 75
Hillman, J. H. 82
Hills, W. H. 33
Hilton, H. G. 69
Himrod, William C. 42
Hinchinbrooke tp.
  Feldspar mining 62
  Mica mining 66
Hinde & Philips 78
Hitchens, H. 67
Hochstetter, Ralph 44

PAGE

Hodgson, F. J. ... 41
Hoisting cables, testing of ... 9
Holden, John B. ... 34
Hollands-Hurst, H. ... 14
Holleford ... 59
Hollinger Consolidated Gold Mines, Ltd.
  Accident at mine ... 4
  Burke claims worked by ... 12, 45
  Operating report ... 34-36
Hologden Mines, Ltd. ... 12, 45
Holloway tp., gold mining ... 30
Home Smith Estate ... 86
Honsberger, H. S. ... 48
Hooper, E. ... 56
Hoppins feldspar mine ... 60
Hore, Reginald E. ... 46
Horton tp., limestone ... 75
Howard tp., gravel and sand ... 83
Howe, Homer H. ... 20
Howes, David J. ... 66
Howes gravel pit ... 81
Howry Creek area, gold mining ... 46
Howry Creek Mining Corp. ... 12, 47
Huffman, J. ... 85
Hugill, A. H. ... 21
Humberstone tp., limestone ... 76
Humphrey's gravel pit ... 81
Hungerford, H. B. ... 67
Hunt, Alex. D. ... 16
Hunter, Andrew W. ... 17, 45
Huntingdon tp., talc mg. ... 67
Huntington, W. Va., nickel plant ... 25
Huntley tp., gravel and sand ... 81
Huray, Stephen J. Le ... 50
Hurd, Ralph ... 42
Hurd, Walter E. ... 41, 42
Hurst, Philip ... 49
Hutchison, R. H. ... 90
Huth, Frank ... 41, 42
Hybinette, Victor ... 24
Hybla, feldspar quarry near ... 62
Hydrated lime ... 71, 75, 76
Hydro-Electric Power Commission.
  Limestone quarry ... 71
Hyland silver mine ... 55

I

Ingolfsrud, L. J. ... 27
Inksater, Jas. R. ... 64
International Feldspar Co. ... 11, 60
International Nickel Co. 4, 14, 24, 68, 69
Interprovincial Brick Co. ... 78
Iron mining ... 11
  Accidents ... 1-8
  Reports ... 17, 21, 22
Instruction classes for prospectors 87-94
Iron pyrites. *See* Pyrites.
Isenbach, W. ... 80
Islet Exploration Co. ... 15, 18

J

Jackfish, gold mg. near ... 15
Jackson, A. H. ... 14
Jackson, Albert J. ... 28
Jackson, Wm. S. ... 16
Jackson Bros. ... 78
Jackson Development Co. ... 12, 16
Jager, Oliver E. ... 24
Jamieson Lime Co. ... 75
Janica, A. ... 4
Jaretzki, Alfred ... 24, 25
Jebsen, Oscar ... 24
Jeffrey, R. T. ... 31
Jensen farm. *See* Golden Summit Mg. Co.
Jessup, Charles ... 46
Jewel Gold and Copper Mg. Co. ... 11, 23
Johnson, George ... 11, 23
Johnson, R. G. ... 83
Johnson Bros. ... 80
Johnston, Albert W. ... 42
Jones, James D. ... 15, 21
Jordan, C. F. ... 40
Jordan, F. S. ... 24
Jorgensen, C. R. C. ... 44
Joy & Son ... 84
Jupiter gold m. ... 38

K

Kakar, Andrew ... 9
Kaladar tp., gold mg. ... 63
Keays, James ... 61
Keays, William ... 60, 61
Kee, H. A. ... 33, 49
Keele, Joseph ... 95
Keeley Silver Mines, Ltd. ... 14
  Report and photo ... 56
Kellen's gravel pit ... 84
Kemp, Charles H. ... 45
Kemp, James ... 69
Kennedy, H. G. ... 57
Kennedy, Murray D. ... 58
Kennedy, Robt. ... 21
Kenogami, gold mg. near ... 30
Kent, William ... 26
Kent co.
  Brick plant ... 78
  Gravel and sand ... 83
Kerr-Addison gold property ... 29
Kerr Lake Mines, Ltd. ... 14, 49
  See also Goldale Mines, Ltd.
Killoran, B. G. ... 41
King, A. R. ... 4
Kingdon Mining, Smelting and Manufacturing Co. ... 65
King-Kirkland Gold Mines, Ltd. ... 12, 40
Kingsley, E. D. ... 68
Kingston, limestone ... 72
Kingston Sand & Gravel Co. ... 83
Kingston Smelting & Refining Co. ... 65
Kirk gold mine ... 12, 21
Kirkham feldspar mine ... 60
Kirkland-Combined Mines, Ltd. ... 12, 40
Kirkland Lake.
  Classes for prospectors ... 87, 88, 92
Kirkland Lake gold area.
  Mining reports ... 40-45
Kirkland Lake Gold Mg. Co. ... 4, 12, 40
Kirkland Lake Proprietary (1919), Limited.
  See Burnside Gold Mines.
    Tough-Oakes Gold Mines.

PAGE

Kitchener, gravel and sand 85
Klein's gravel pit 84
Knight, H. W. 33
Knight, J. J. 49
Korah tp., gravel pit 80
Kraft, Harry N. *See* Orser-Kraft.
Krakowiak, Thomas 17
Kramer, G. 4

L

Labelle, F. A. 29
Lacey mica mine 14, 66
Ladd, Clarence H. 21
Lahay, L. J. 46
Lake Shore Mines, Ltd. 12, 41
Lake Superior Corporation 21
Law, E. G. 76
Lawson, W. B. 24
Lawson tp., silver 58
Lambert, E. 69
Lanark co.
  Brick plant 78
  Gravel and sand 83
  Granite and limestone 73
Landagne gold claims 45
Langer, Dr. Carl 27
Langmuir tp., gold mg. 39
Langworthy, W. F. 16
Larder Lake gold area.
  Mining reports 29-31
La Rose Mines, Ltd. 14, 50, 51
Latilla, H. G. 44
Lead mining 14, 65
Learn, E. 82
Lebel tp., gold mg. 40, 42
Lee, George 89
Lee, S. Robert 83
Leeds co.
  Gravel and sand 84
  Stone quarrying 73, 74
Leeds tp.
  Granite 74
  Syenite 73
Leeson, Vincent 80
Lefaivre 75
Legate, William 83
Lennox and Addington co.
  Brick plant 73
  Gold mining 63
  Gravel and sand 84
  Stone quarrying 74
Leonard, R. W. 48, 68
LeSueur, R. V. 33
Leszcynski, Edward 20
Levack nickel mine 14, 27
Levy l. *See* Collins s.m.
Lewisohn, Adolph 49
Lightfoot, S. 28
Lightning River Gold Mines, Ltd. 12, 30
Limestone.
  Quarrying 71-77
    accidents 1-9
Lincoln co.
  Limestone quarries 74
Livingstone, G. Robert 20
Little Silver hill 53

PAGE

Little Silver vein 53
Little Stonehouse l. 62
London, brick plant 78
London tp., gravel pit 84
Long lake, Frontenac co.
  Feldspar quarry 60
Longmore, ... 92
Longwell, Alex. 48, 68
Longworth, W. L. 16
Lorrain Operating Co. 55
Loughborough tp.
  Feldspar quarrying 60, 62
  Mica mining 66
Loughborough Mining Co. 14, 66
Louth tp., limestone 74
Lovelace, F. L. 40
Low, F. S. 68
Lower Rock l. 62
Lucy, Dr. R. 30
Lucy, William J. 30
Lycett, James 21
Lythmore, gypsum 64
Lytle, Rev. Jas. 92

M

McAllister, W. M. 85
McAlpine, D. 82
McAlpine, Ont. 72
McArthur, Duncan 80
McArthur, T. A. 91
McAuley, N. J. 91
McAuley, P. L. 84
McCarthy, T. B. 25
MacCaskill, Donald 26
McColl, W. J. 83
McColl Bros. 82
McConnell, Ricardo 11, 60
McCrea, Charles 46
McDonald, J. 21
McDonald, John A. 23
McDonald, Peter 26
Macdonald & Dibble 75
Macdonald feldspar quarry 12, 62
Macdonald l., Asquith tp. 45
MacDonell, W. A. 27
McDougald, Wilfred L. 34
McGaughey, Charles S. 45
McGibbon, D. Lorne 50
McGregor, D. G. 78
McGregor feldspar mine 59
Machin, H. A. C. 13, 17
McInnis, Israel 83
McIntyre Porcupine Mines, Ltd. 13
  Accident at mine 4
  Mining report 37, 38
Mack, A. A. 41
Mackan, J. J. 48, 68
McKay, Prof. G. J. 87
McKay, F. H. 84
McKay, J. A. 39
McKay, W. J. L. 67
McKellar, D. 16
McKellar, Peter 16
McKellar-Longworth gold m. 13, 16
McKerrow, William 28
McKnight Construction Co. 84

PAGE
McLaren, George R. 13, 22
McLaren limestone quarry 71
McLean, J. A. (Chesterville) 81
McLean, J. A. (Detroit) 11, 60
McLennan, Ont. 28
McLoughlin, J. M. 78
McMann, Robt. 28
McMillan, J. G. 1, 11
MacMurchy tp.
  Gold mg. *See* White Rock Mg. Co.
McNamara Bros. and Thornton 85
McNaughton, George W. 14, 66
McNiven, P. 67
McPhee copper mine 22, 23
McPherson, Wm. B. 46
McTierman, J. 75
McVichie, J. A. 15, 55
McVittie, J. 13
McVittie, William 46
McVittie tp., gold mg. 30
Madoc.
  Fluorite mg. near 63
  Instruction classes 87-89
Magpie iron m. 13, 22
Maher, W. 86
Mahon, G. W. 54
Mahon, J. C. 46
Maisonville tp., gold mg. 30
Majestic Gold Mines, Ltd. 12, 47
Malahide tp., gravel and sand 82
Maloney, J. 76
Manitou Lake area.
  Gold mg. *See* Grace g.m.
Manley, A. J. 46
Manson, J. T. 68
Maple Sand, Gravel and Brick Co. .. 86
Marble quarries 73
Marcelis, C. 82
March tp., gravel and sand 82
Marchand, L. J. 29
Marks, J. 64
Marks, J. E. 89
Markus, William 75
Marlborough tp., gravel 81
Marsh, A. W. 67
Marsh, George H. 17
Marshall & Sons, Jas. 76
Martin, Hart 45
Martin, Miss N. F. 59
Martindale, Gilbert 83
Mason, William Thomas 40
Mason-Wilcox iron m. 13, 22
Masters, Adna K. 20, 21
Masterton, W. K. 55
Matachewan l., gold mg. 45
Matheson, J. 14
Matheson, Ont.
  Gold mining near 30
Matheson estate 66
Mathias, Robert 27
Mattagami r., clay 95, 96
Matthews, W. H. 48
Meaford Brick Co. 78
Medonte tp.
  Gravel 85
  Limestone 75
Mein, W. W. 25
Mendels, Joseph H. 11, 59

PAGE
Merkley's Limited 78
Mersea tp., gravel 82
Messecar, C. L. 21
Metallurgical works 15
  Accidents 1-8
  Operating reports 67-69
Metler, Edgar 85
Metz, Gustav 61
Meyer, Peter 80
Meyer, William H. 41
Mica mining 14, 66
Michipicoten area, gold mg. 20
Middlesex co.
  Brick plant 78
  Gravel and sand 84
Middleton, John N. 76
Midlothian tp., gold prospecting 93
Mierzynski, Joseph 17
Mikado Consolidated Mines, Ltd. 13, 17
Millar, Charles 45
Miller, Edwin Lang 44
Miller, G. C. 31, 42
Miller, Gerard F. 44
Miller, J. A. 74
Miller, W. N. 89
Miller-Adair Mines, Ltd. 13, 45
Miller Independence Mines, Ltd. . 13, 28
Miller Lake O'Brien silver m. .. 14, 57
Mills, Geo. E. 79
Milne, John E. 66
Milton 78
Milton Pressed Brick Co. 78
Minehart, A. G. 11, 61
Miner & Son, John T. 78
Mines.
  Accidents 1-10
  Development reports 11-69
Mining Corporation of Canada 14
  Accident at mine 4
  Report 51, 55
Missinaibi r., clay 95, 96
Mitchell, Arthur 13, 17
Mitchell gravel pit 81
Mitchelson, Sir Archibald 38
Moir, Dr. A. 23
Molybdenite, Monmouth tp. 66
Molybdenite Products Co. 66
Mond, Emile S. 27
Mond, Robert L. 27
Mond Nickel Co. 14
  Accident at mine 4
  Mining report 27, 28
Monel Metal Products Corp. 25
Monteagle tp.
  Feldspar 60-62
  Molybdenite 66
Montreal-Kirkland Mines, Ltd. .. 13, 41
Montreal-Ontario Mines, Ltd. 41
Monumental stone 73, 74
Moody, Wm. H. 23
Mooney & St. Denis 75
Moore, George 83
Moore, M. 63
Moore, William M. 39
Moose Mountain, Ltd. 13, 22
Moran, John 63
More, John 15, 24, 69
Morgan, C. E. 92
Morgan, J. W. 89

PAGE

Morgan, M. R. 93
Morrison, G. A. 26
Morrison, J. W. 12, 29, 30
Morrison, Thos. 25
Morrow, James 61
Morrow feldspar mine 11
Morton, John 55
Morton, W. L. 16
Mountain tp., limestone 72
Mount Dennis 86
Mount Eagle Feldspar Co. 11, 60
Mulcahy, Carl W. 20
Mumford, W. J. 14, 27
Munich, A. G. 65
Murdock, James Y. 33
Murphy gold claim 12, 20
Murray nickel mine 14, 24
Murray tp., gravel pits 84
Muscovite. *See* Mica.
Muskoka dist., gneiss quarrying 74
Mutch, D. A. 15
Myer silver m., accident 4
Myhill, William S. 62

N

Napanee.
  Gravel and sand 84
  Town of, working road material 74
Neebish islds., quartzite 71
Nelson, J. C. 45
Nelson, Johnson 83
Nelson, K. 48
Nepean tp.
  Gravel pit 81
  Limestone quarries 71, 72
Newell, H. 82
Niagara Alkali Co. 68
Nichol tp., lime kilns 76
Nichols, John 25
Nichols Chemical Co. 4, 18, 64
Nickel and copper.
  Mining accidents 1-8
  Mining reports 22-27
Nickelton smelter 24
Night Hawk l. 39
Night Hawk Peninsula Mines, Ltd. 39
Nilsen, A. 4
Nipissing Mines, Ltd. 4, 52-54
Noble, S. W. A. 27
Noonan, William D. 61
Norfolk co., gravel and sand 84
North Bay, classes for prospectors 87, 88, 93
Northcliff Mines, Ltd. 57
Northcrown Porcupine Mines, Ltd. 38
Northland, iron mg. near 22
Northpines pyrites mine 4, 18
Northumberland co.
  Gravel and sand pits 84
Northwestern Ontario.
  Mining reports 15
Norton, Alsey 73

O

Oakes, Miss G. 92
Oakes, Harry 41
Oakland tp., gravel pits 80

PAGE

O'Brien, J. A. 54
O'Brien, M. J. 54, 68
  See also Miller Lake O'Brien.
O'Brien and Fowler 60
O'Brien silver mine 54
O'Donnel rapids, Skootamatta r. 63
Oelheim, Charles 16
Offer, W. C. 92
Ogden tp., gold mining 31
Ogilvie, Shirley 50
O'Halloran feldspar quarry 59
Ohl, E. N. 28
Oliver, Dr. 90
Ollman, F. R. 85
Oneida tp., stone quarrying 73
Ontario co., quarrying in 75
Ontario reformatory, Guelph 4, 76
Ontario Dolomite Mfg. Co. 58
Ontario Gypsum Co. 64
Ontario-Kirkland Gold Mines, Ltd. 41, 42
Ontario Porcupine Goldfields Dev. Co. 33
Ontario Rock Co. 75
Ontario Sewer Pipe Co. 79
Ontario Smelters and Refiners, Ltd. 69
Ophir gold mine 21
Ore Chimney Mg. Co. 63
Orford nickel plant, Bayonne, N.J. 25
Orillia tps., limestone 75
Orr, Guy H. 85
Orser, Miss D. M. 61
Orser, E. 61
Orser, Sherman 60
Orser, Sidney H. 60
Orser-Kraft Feldspar, Ltd. 60, 61
Osgoode tp., limestone quarry 71
Osler, Britton 24, 25
Ostrowski, James 17
Otonabee tp.
  Brick plant 79
O'Toole, John 59
Ottawa.
  Limestone quarries 71
Ottawa Improvement Commission 71
Ottawa Suburban Roads Commission 71
Ottawa Brick & Tile Co. 79
Owen Sound.
  Brick plant 78
  Gravel and sand 83
  Limestone 72
Owen Sound Brick Co. 78
Oxford co., quarrying in 75
Oxford tp., limestone 72, 76
Oxford Cobalt Silver Mines, Ltd. 54

P

Pacaud tp.
  Gold mining 28
Page, Jacob 85
Painkiller gold mine 30
Paipoonge tp.
  Silver. *See* Federal Mg. Co.
Paisley, gravel pits 80, 81
Palatine iron mine 17
Palmer feldspar mine 61
Palmerston tp., calcite quarrying 59
Paris, T. M. 27

PAGE

Paris Sand & Gravel Co. 80
Park, Hugh 52
Parker, W. R. P. 51
Parkhurst, A. J. 64
Parkhurst, W. A. 64
Parks, H. W. 78
Patno, John D. 64
Patterson, A. 55
Paulson iron mine 17
Paving blocks 73, 74
Peacock, D. C. 18
Peddy, L. 29
Peek, R. L. 48
Peel co., brick plants 78
Pelham tp., gravel and sand 85
  Limestone 76
Pellatt, Henry M. 37
Peloquin, J. B. 41
Pennell, Edward M. 21
Pennsylvania Pulverizing Co. 61
Perth, feldspar quarries near 59
Perth co.
  Gravel and sand pits 84
  Limestone quarries 75
Perth Road, lead mining near 65
Peterborough, gravel quarry 84
Peterborough co.
  Brick plant. *See* Hawkesbury.
  Gravel and sand pits 84
  Limestone quarries 75
Peter McDonald farm. *See* McDonald feldspar quarry.
Peters, ... 67
Pfeiffer, P. C. 52
Phillips, E. 67
Phlogopite. *See* Mica.
Picton, gravel quarrying 84
Pirson, J. 76
Pittsburgh tp.
  Granite gneiss 74
  Limestone 72
Plantagenet tps., limestone 75
Plaster board 64
Plummer tp., copper mining 22
Plunkett, Thomas 51
Poillon, Howard 31
Point Anne 73
Pollock, Alex. 27
Pomeroy, Robt. W. 42
Ponsford, A. E. 82
Poole, F. C. 82
Pooley, Charles A. 28
Pope, A. 4
Pope gold claim 39
Porcupine gold dist.
  Mining reports 31-40
Porcupine Davidson Gold Mines, Ltd. 13, 38
Porcupine Keora Mining Co. 13, 39
Porcupine Peninsular Gold Mines, Ltd. 13, 39
Port Arthur, classes for prospectors 87-89
Port Colborne.
  Blast furnace, refinery 15, 24, 25, 67-69
  Limestone 76

PAGE

Port Elgin.
  Brick plant 78
  Gravel pit 80
Porter, A. R. 20
Portland tp.
  Feldspar quarrying 59
Post, Charles B. 39
Potter, Charles Edward 69
Powers, F. W. 28
Prescott co., quarrying 75
Price, A. E. T. 49
Price & Smith 79
Price talc claim 67
Prince tp. 28
Prince Edward co.
  Gravel and sand pits 84
  Road making 75
Princess silver mine 50, 51
Prior, E. M. 82
Prosecutions (Mining Act) 9
Prospectors, Instruction classes for 87-94
Prosser, Seward 25
Proton 83
Puslinch tp., limestone 76
Pyrites.
  See Northpines.
    Rand Consolidated.
    Sulphide, Ont.

Q

Quarries.
  Accidents 1-9
  Operators 70-77
  Quartz. *See* Dill.
Quartz, Ont. *See* Dill quartz quarry.
Quartz for flux. *See* Flux.
Quartzite.
  Algoma dist., for roads 71
Queen-Lebel Gold Mines, Ltd. 42
Queenston Quarry Co. 74
Quinn, Clement A. 17

R

Racuba, D. 4
Rainville, J. H. 29
Raleigh tp., sand pit 83
Rama tp., gneiss quarry 75
Ramsay tp., crystalline limestone 73
Rand Consolidated Mines, Ltd. .. 14, 28
Rawlins, James W. 26
Ray, Col. S. W. 89
Raymond, A. 29
Rea, E. A. 54
Rea, T. H. 33
Reamsbottom, W. H. 20
Redden, Henry 84
Reid, A. J. 67
Reid, Fraser D. 48
Reider, T. H. 41
Reliance silver mine 54
Renfrew.
  Limestone quarry 75
Renfrew co.
  Brick plant. *See* Arnprior.
  Gravel pits 84
Renwick, John 64
Rhodes, E. N. 24

PAGE

Ribble Mines, Ltd. ... 46
Richards, Robert R. ... 20, 21
Richards, William J. ... 16
Richardson, U. ... 30
Richardson feldspar mine ... 59
Rideau canal.
  Limestone quarrying ... 71
Ridgeville Concrete Works ... 85
Riley, Charles W. ... 15
Road material ... 70-86
Robertson, Charles M. ... 56
Robertson, J. F. ... 27
Robertsville, calcite near ... 59
Robinson, John ... 61
Robinson, L. V. ... 64
Rock lakes, Storrington tp. ... 62
Rockcliffe, sand and gravel ... 81
Rock Products Co. ... 60
Rockwood, limestone ... 76
Rodda F. ... 90
Rogers, George R. ... 46
Rogers, R. P. ... 48
Rogers, Richard B. ... 23
Rognon, E. R. ... 15
Rolfe, W. J. ... 25
Rollins, D. W. ... 78
Romney, sand pit ... 83
Rosa, Savario D. ... 45
Roscoe, H. L. ... 24
Rose, E. H. ... 51
Rose, R. R. ... 66
Rose tp., copper mining ... 22
Ross, Walter ... 16
Rudd, S. R. ... 82
Russell, J. W. ... 54
Russell, W. H. ... 16
Russell Co., John E. ... 83
Russell.
  Brick plant ... 79
Russell co., quarrying ... 75
Russell tp., limestone ... 75

S

St. Anthony gold m. ... 17
St. Anthony l., gold mg. ... 31
St. Charles, Dr. W. P. ... 41
St. George, M. J. ... 17
St. Jean Bros. ... 82
St. Mary r. ... 28
St. Mary's Cement Co. ... 75
St. Vincent tp., brick plant ... 78
Saltfleet tp.
  Limestone quarries ... 77
  Sand and gravel ... 86
Sand and Gravel.
  Accidents in working ... 1-9
  Missinaibi river ... 95
  Operators and pits ... 80-86
Sand and Supplies, Ltd. ... 85
Sanderson silver claims ... 58
Sandstone quarries ... 71
Sarjeant Co. ... 85
Sass, William T. ... 42
Sault Ste. Marie.
  Classes for prospectors ... 87-89
Scarboro tp., sand and gravel ... 83
Schreiber, gold mg. near ... 16

PAGE

Scott, F. S. ... 85
Scott, J. G. ... 85
Scott, J. Ralph ... 59
Scott & Nicholson ... 84
Seitz, Leo B. ... 61
Selick, A. ... 4
Selkirk, A. V. J. ... 20
Sellwood, R. M. ... 18
Sellwood, Ont. ... 22
Seneca tp.
  Gypsum. *See* Caledonia.
Serpell, William J. ... 27
Sesekinika.
  Gold mining near ... 30, 40
Sewer pipe plants ... 79
Seymour, William ... 21
Shaff, Henry ... 30
Shaff, John ... 30
Shakespeare tp., copper mg. ... 23
Sharp, Capt. A. L. ... 27
Shaw, John M. ... 28
Shaw, J. R. ... 54
Shaw tp., gold mg. ... 39
Shelley, Geo. ... 82
Shephard, Barry ... 93
Sheppard, W. J. ... 37
Sherbrooke tps., mica and feldspar 61, 66
Sherkston, gravel and sand ... 76
Shields, W. J. ... 45
Shirk, G. M. ... 85
Shoefelt, Jacob ... 12
Shoefelt silver claim ... 12, 28
Shoemaker, A. ... 85
Shovel, William ... 27
Silica, Ohio ... 61
Silver mines ... 14, 15
  Accidents ... 1-8
  Mining reports ... 18, 47-55
Silver Cliff silver m. ... 15, 47, 55
Silver Islet silver m. ... 15, 18, 19
Silver Queen silver m. ... 15, 55
Simcoe co.
  Gravel pits ... 85
  Stone quarrying ... 75
Simms, Frank ... 27
Simpson H. K. ... 44
Simpson, W. E. ... 28
Sixt, W. M. ... 12, 40
Skead tp.
  Gold mining. *See* Skead Gold Mines, Ltd.
Skead Gold Mines, Ltd. ... 31
Skidoo l. ... 30
Skootamatta river ... 63
Slaght, Arthur G. ... 41
Slee, Frederick ... 68
Sligh, Charles R. ... 21
Sloane gravel pit ... 83
Slush, T. H. ... 84
Smallwood, F. ... 21
Smelters.
  See Blast furnaces.
    British American Nickel Corp.
    Copper Cliff.
    Port Colborne.
Smith, Albert ... 4
Smith, E. A. Cappelen ... 24

PAGE
Smith, H. B. 4
Smith, H. Coleman 20
Smith, Richard 66
Smith, Robert M. 58
Smith Bros. 78, 80
Smith tp., gravel pits 84
Smiths Falls, limestone quarry 73
Smith-Labine gold claims 40
Smyth, C. 86
Smythe, W. R. 45
Somerville tp., limestone 75
Soule, W. H. 27
South Cedar Springs 83
Southern Ontario.
  Mining reports 58-86
South Lorrain tp.
  Silver mg. 55-57
South Porcupine.
  Classes for prospectors 87, 88, 92
Southworth, Thomas 68
Spada, L. 4
Sparling, Fred. W. 20
Spauling, Willis M. 33
Spawning l. 57
Speer, C. H. 21
Spratt, J. A. Harvey 82
Sprecher, G. A. 25
Sproat, George R. 45
Stamford tp.
  Gravel and sand pits 85
  Limestone for flux 76
Standard Brick Co. 79
Standard Chemical Co. 75
Standard White Lime Co. 4, 75
Stanley, John 82
Stanley, R. C. 24, 25
Stansbury, Edwin 48
Starke, Col. Robt. 38
Steel Company of Canada 15, 69
Steele, Edwin G. 79
Stenbol, Carl 21
Stern, Morton F. 31
Stevenson, P. C. 24
Stevenson, William 46
Stewart, H. J. 30
Stoddard, John 82
Stokloser, Karl 89
Stone. *See* Building stone; Granite; Limestone; Trap; Sandstone.
Stonehouse l. 62
Stormont co., quarrying 75
Storrington tp.
  Feldspar mining 62
  Gravel pit 83
Storrington Feldspar Co. 62
Stothart, Jas. 84
Street & O'Brien 74
Streetsville Brick Co. 78
Strong, H. F. 55
Sturgeon falls, Mattagami r. 37
Sudbury.
  Classes for prospectors 87-90
Sudbury dist.
  Gold mg. 29
  Nickel. *See* Nickel.
Sullivan, Joseph T. 21
Sullivan, Roy 57

PAGE
Sun Brick Co. 79
Sutherland, H. H. 38
Sutherland, T. F. 1, 11
Swansea, brick plant 79
Swartz, John 40
Swastika, classes for prospectors 87, 88, 91
Sweeney, W. R. 47
Sydenham, mica mg. near 66
Syenite.
  Leeds tp., for monuments 73

T

Tack, Henry 84
Tarbutt tp., silver prospecting 28
Taylor, Alexander 21
Taylor, C. H. 30
Taylor, Charles O. 57
Taylor, Frank 26
Taylor, L. 86
Taylor, T. 89
Tebbutt, John T. 41
Teck-Hughes Gold Mines, Ltd.
  Mining report 42, 43
  Prosecution under mg. act. 9
Teeples, Alexander 62
Teeples feldspar claim 12, 62
Teeswater 71
Telfer, R. A. 64
Terracotta.
  Gloucester tp. 78
Terrill, Albert 20
Thames Quarry Co. 75
Thaw, William 39
Theaker, W. 86
Thesaurus Gold Mines, Ltd. 13, 45
Thomas, Hon. I. B. F. 38
Thomas, Matthew 39
Thomas, W. R. 13, 44
Thompson, C. 14
Thompson, C. H. 66
Thompson, C. N. 65
Thompson, E. J. 14, 57
Thompson, J. F. 42
Thompson, Robt. H. 11, 61
Thompson, S. C. 44
Thompson, Stephen G. 23
Thompson-Krist gold m. 38
Thorold, smelter 15,68
Thunder Bay dist.
  Silver mining 18, 19
Thurlow tp.
  Brick plant 78
  Limestone quarry 73
Tichborne.
  Feldspar mg. near 59, 62
  Mica mg. near 66
Tile plants 78, 79
Timmins, Jules, R. 34
Timmins, L. H. 34
Timmins, Noah A. 34
Timmins, Ont.
  Classes for prospectors 87, 88, 92
  Gold. *See* Hollinger Consolidated.
Timmins feldspar quarry.
Todd, W. H. 15, 28
Tolman, C. M. 22

PAGE
Tomlinson, B. C. 24
Tompkins, G. 4
Torbolton tp., limestone 75
Toronto tp., brick plant 78
Toronto Brick Co. 76, 79
Tough, George 40
Tough, R. B. 12
Tough, Thos. B. 57
Tough-Oakes Gold Mines, Ltd. 13, 43, 44
Tower, William O. 25
Townsend tp., gravel and sand 84
Trafalgar tp., brick plant 78
Trafford, C. E. 51
Train, Mr. 91
Treleaven, R. A. 30
Trethewey Silver-Cobalt Mining Co. 15, 58
Triplex Gold Mines, Ltd. 13, 39
Troop, Stewart 15, 58
Tudor tp., lead mining 65
Tuke, W. H. 91
Turczynowicz, Roman 17
Turk, E. 56
Turner, Scott 51
Tycoon gold mine 17
Tyendinaga tp., limestone 73
Tyrrell, J. B. 41

U

Union Gold Mines Trust, Ltd. 40
Union Mining Corp. 13, 40
Universal Silicates, Ltd. 60
University silver mine 14, 50, 51
Upper Rock l. 62

V

Vanderlip, Joseph H. 23
Vander Voort, M. P. 20
Van Hise tp., silver mg. 57
Vanluven, Albert 12, 62
Vaughan tp., sand and gravel 86
Vernon 71
Verona 59
Verona Mining Co. 62
Victoria co.
  Limestone quarrying 75
Victoria nickel mine 14, 27
Victoria silver mine 4
Victory Silver Mines, Ltd. 15, 55
Violet silver mine 14, 50, 51
Vogt, D. 24

W

Wachman gold m. 17
Wagar, Richard 11, 59
Waide, J. C. 78
Wainfleet tp., limestone 76
Waite, J. C. 13, 39
Wallbridge, C. W. 89
Wallbridge Bros. 12, 63
Walker, Arthur 4
Walker, Sir Edmund 27
Walker, George 30
Walker Bros. 76
Wallace gravel pit 81
Walpole tp., stone quarrying 73

PAGE
Walton, C. G. 12, 62
Wangler, William 82
Wanless, G. A. 42
Warren, F. A. 66
Warwick Brick Works, Ltd. 78
Wasapika lake. *See* White Rock Gold Mg. Co.
Wasapika Consolidated Mines, Ltd. 13, 46
Washago limestone quarry 4
Washburn, J. L. 18
Washington, J. L. 18
Watabeag r., waterpower 30
Waterdown 77
Waterloo co.
  Brick plant. *See* Kitchener.
  Gravel and sand 85
  Stone quarrying 76
Waterloo tp. 85
Waterpower, Skootamatta r. 63
Watson, Alex. 11, 58
Watson, A. H. 89
Watson, C. G. 93
Watson, J. G. 51
Watson, J. P. 51
Watson, R. B. 52
Watson feldspar claim 11, 60
Watts, N. 89
Wawa l. 21
Webbwood, copper mg. near 23
Webster, A. R. 1, 11
Weir's gravel pit 84
Weldon, Robert P. 21, 22
Welland, smelter 69
Welland co.
  Gravel and sand 85
  Limestone quarrying 76
Wellington co.
  Gravel and sand 85
  Limestone quarrying 76
Wells, R. G. 69
Wende, Albert 13, 41, 44
Wentworth co.
  Brick plants 79
  Gravel and sand 85, 86
  Limestone 76, 77
Wentworth Quarry Co. 77
Westlake, E. A. 49
West Lake Brick & Products Co. 84
West River station 47
West Shiningtree Lake dist.
  Gold mining 45, 46
West Toronto, sand and gravel 86
Wettlaufer, C. E. 40, 41
Whitby, O. W. 64
White, Homer 84
White, J. T. 17
Whitefish lake, Brougham tp. 64
White Rock Mining Co. 13, 46
Whitesides tp., gold mg. 40
Whitney tp.
  Gold. *See* Porcupine Keora.
Wiarton, limestone 71
Wigren, Eugene A. 20
Wigwam, Ont. 58
Wilberforce molybdenite m. 14
Wiley, Mr. 14
Wilkes, John 59

PAGE

Williamsburg tp.
  Gravel and sand pits 81, 82
Williamson, J. C. 56
Wilson, A. H. 54
Wilson, E. R. 23
Wilson, Joseph W. 21
Wilson, Dr. S. C. 60
Wilson & Sons, Samuel 78, 80
Winchester tp.
  Gravel and sand 81
Windmill Point 72
Windsor Brick & Tile Co. 78
Windsor Sand & Gravel Co. 82
Wink, A. S. 90
Winning limestone quarry 75
Wolfe, W. E. 89
Wollaston tp., limestone quarry 73
Wood, E. B. 13, 42
Wood, E. E. 90
Wood, E. R. 24
Wood, W. G. A. 92
Woodcock feldspar mine 11, 61
Woodland, H. 4
Woodland, W. 4
Woods, William J. 61
Wood's vein, Keeley s.m. 56
Workman, J. K. 26
Workman's Compensation Act 1, 2
Worth, S. Harry 63
Worthington nickel mine 14, 28
Wright, John C. 78

PAGE

Wright, S. B. 15, 68
Wright, Wm. H. 41
Wright & Co. 80
Wright-Hargreaves Mines, Ltd. 13
  Mining report 44, 45
Wydra, Frank 17
Wylie, B. M. 89

Y

Yarmouth tp.
  Gravel and sand 82
Yates, Harry 68
Yeo I., sand brick 84
Yonge tp., gravel and sand 84
York co.
  Brick plants 79
  Gravel and sand 86
York tp. 86
York Sand and Gravel Co. 86
York Sandstone Brick Co. 86
Young, A. J. 47
Young, Horace G. 21
Young, W. 74

Z

Zander, Hugo 21
Zettler, Andrew 81
Zettler, William 81
Zolkowski, A. 17

Gov.Doc. 194396
Ont Ontario. Legislative Assembly
L Sessional papers.
Vol.54, pt.2 (1922)

University of Toronto
Library

DO NOT
REMOVE
THE
CARD
FROM
THIS
POCKET

Acme Library Card Pocket
Under Pat. "Ref. Index File"
Made by LIBRARY BUREAU

Gov. Doc.
Ont
L

Ontario. Legislative Assembly
Sessional paper
Vol. 54, pt. 2, 1922

Map Nº 31d.

WATABEAG AREA

NOTES

The Watabeag Area is situated partly in the district of Timiskaming and partly in the newly created district of Cochrane, about 450 miles north of the city of Toronto. Good wagon roads lead from the towns of Matheson, Ramore, Yorkston and Bourkes, stations on the Temiskaming and Northern Ontario Railway, to the eastern portion of the area. Canoe routes shown on the map have all been travelled, and portages re-cut and blazed where necessary.

The discovery of gold in Playfair township ranks among the first in point of time in northeastern Ontario. Claims were also staked for gold in the townships of Egan, Timmins and Terry more than a decade ago, but so far no production has come from the area. At present only a few mining claims have been staked in any of the townships, and the area has received little or no attention from the prospector since 1910.

The area is from 850 to 1300 feet above sea level. The only area of agricultural lands of important size is in the townships of Playfair, Egan, western McCann and eastern Sheraton.

Much of the forest, particularly in Playfair and in the sand country, has been burned and re-burned, yet much valuable timber still remains.

The magnetic declination within the area varies usually between 9° and 11° west of north. Some variations from this have been noted on the map.

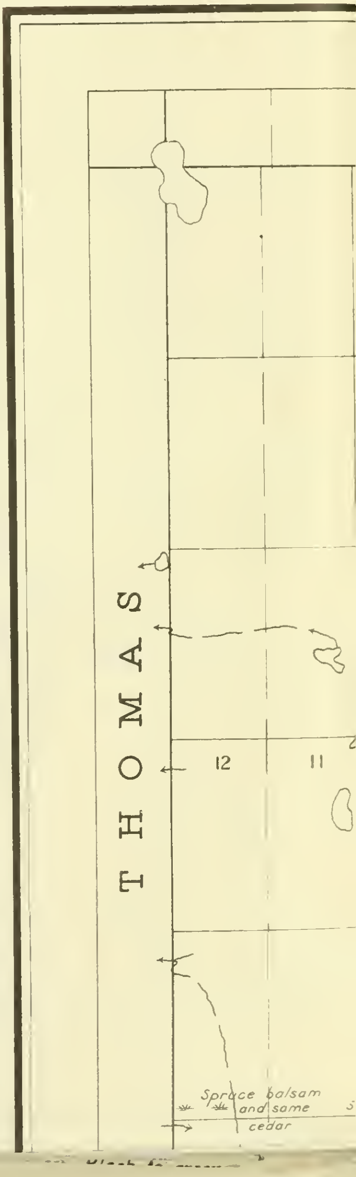
Geology

The legend accompanying the map gives the rock relationships as recognized in the field. Only field names are used on the map, as the reconnaissance nature of the report did not warrant a more intensive study or microscopical classification.

The following is a brief description of the rocks beginning with the oldest:—

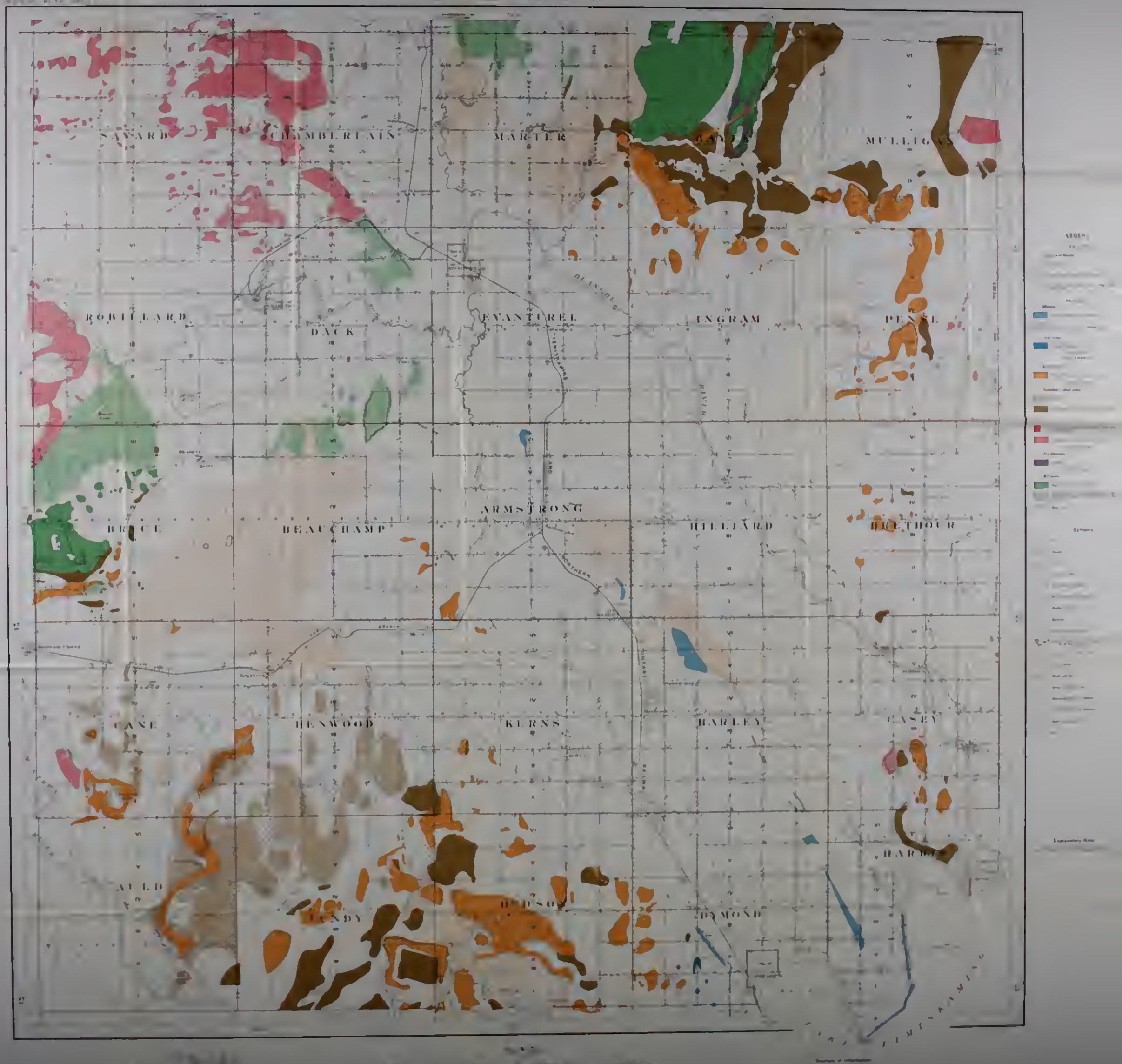
Keewatin.—The Keewatin rocks in the area are considered to be an orderly succession of lava flows, basic for the most part, consisting of amygdaloidal pillow lavas, and fragmental material. These rocks, remote from the batholithic intrusion of granite are generally massive, schistosity being only local. The rocks about the periphery of the granite batholith have been largely altered to hornblende, chlorite and sericite schists, the first named predominating. Other Keewatin rocks are serpentine, rhyolite, and a heterogeneous clastic fully described in the text.

Algoman.—The central and western fringe of the area is occupied by a granite batholith, with syenite porphyry facies. Granite gneiss occurs locally throughout the area occupied by the batholith. Surrounding the batholith, many granite, syenite and acid porphyry



[illegible]
[illegible]
[illegible] 2, 1922

PROVINCE OF ONTARIO



BLANCHE RIVER AREA

DISTRICT OF TIMISKAMING ONTARIO

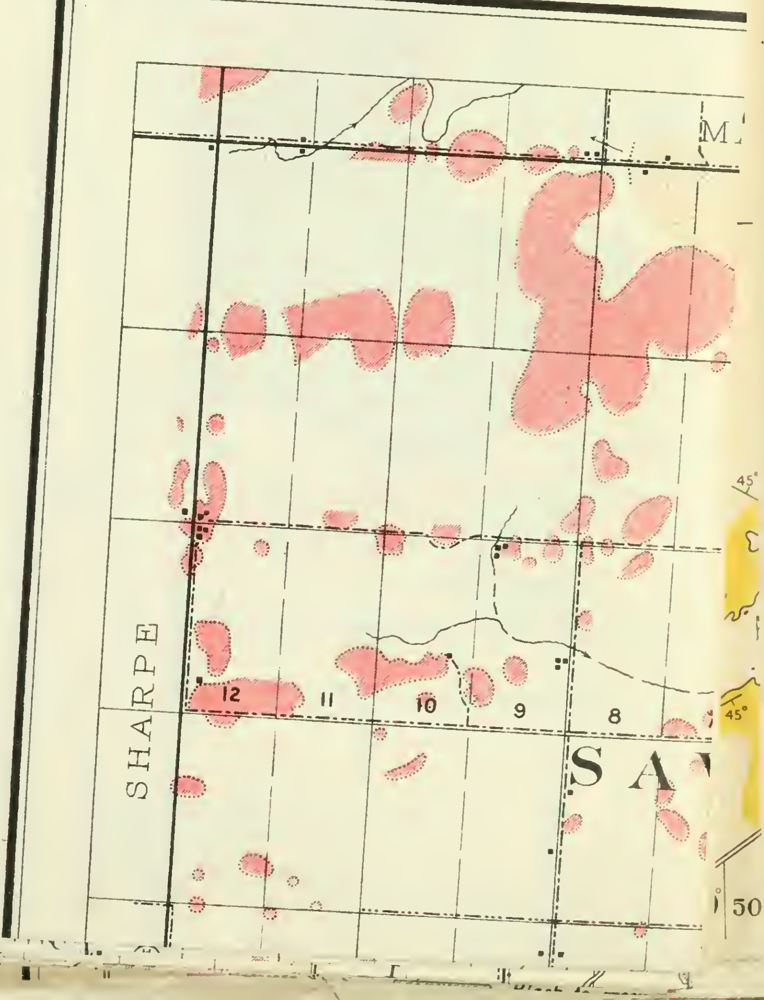
5 maps in

Gov. Doc.
Ont
L

Ontario. Legislative Assembly
Sessional papers.
Vol. 54, pt. 2, 1922

Map No. 31b.

BLANCHE RIVER AREA



Gov. Doc. Ont L Ontario Legislative Assembly Sessional papers Vol 54, pt 2, 1922

Map No 31d
WATABEAG AREA

PROVINCE OF ONTARIO
DEPARTMENT OF MINES

Hon H Mills, Minister of Mines — Willet G Miller, Provincial Geologist

NOTES

[illegible] Watabeag Area is situated partly in the [illegible] Timiskaming and partly in the newly created [illegible] Cochrane about [illegible] miles north of the [illegible]. Good wagon roads lead from the [illegible] Matheson, Ramore, Kelso and Bourkes [illegible] on the Temiskaming and Northern Ontario Railway to the eastern portion of the area. Canoe routes [illegible] on the map have all been travelled and portages cut out and [illegible] where necessary.

The discovery of gold in Playfair township ranks among the first in point of time in northeastern Ontario. Claims were also staked for gold in the townships of Egan, Timmins and Terry [illegible] for no production has come from [illegible] a few mining claims have been staked [illegible] and the area has received little attention from the prospector since 1910.

The area is from 950 to 1,100 feet above sea level. The [illegible] agricultural lands of important size [illegible] in the townships of Playfair, Egan, western McCann and eastern Sheraton.

Much of the forest, particularly in Playfair and [illegible] has been burned and re-burned [illegible] valuable timber and remains.

The magnetic declination within the area varies [illegible] between 9° and 11° west of north. [illegible] taken from this have been noted on the map.

Geology

The legend accompanying the map gives the rock relationships as recognized in the field. Only field names are used on the map as the reconnaissance nature of the report did not warrant a more intensive study or [illegible] classification.

The following is a brief description of the rocks beginning with the oldest.

Keewatin.—The Keewatin rocks in the area are considered to be an [illegible] of lava flows, composed for the most part consisting of amygdaloidal pillow lavas and fragmental material. These rocks, remote from the batholithic intrusion of granite, are generally massive, schistosity being only local. The rocks about the periphery of the granite batholith have been largely altered to hornblende, chlorite and sericite schists, the first named predominating. Other Keewatin rocks are serpentine, rhyolite and a heterogeneous [illegible] fully described in the text.

Algoman.—The central and western fringe of the area is occupied by a granite batholith, with syenite porphyry facies. Granite gneiss occurs locally throughout the area occupied by the batholith. Surrounding [illegible] and porphyry dikes intrude the Keewatin rocks.

Matachewan.—Dikes and sills of diabase belonging to this age are to be found with a widespread distribution throughout northeastern Ontario. The dikes [illegible] of [illegible] age are frequently characterized by phenocrysts of labradorite feldspar sometimes one or two inches in diameter. The phenocrysts have a greenish yellow waxy appearance due principally to sericitization and kaolinization. Other diabases which petrographically are practically identical with the Nipissing diabase are also found. The dikes usually strike in a northerly direction. The name has recently been given to the series by A. G. Burrows who has studied it in both the Matachewan and Gowganda areas.

Cobalt Series.—This series is composed of slate, slate-like greywacke, greywacke and a conglomerate containing boulders of a reddish granite and usually rests unconformably on either a basic Keewatin or Algoman granite floor. This series in the Watabeag area is not thought to be of economic importance as it is so far as observed in the field free from intrusive action from the Nipissing diabase. Being of a later age than the gold bearing veins of northeastern Ontario [illegible] Cobalt series [illegible] cannot be expected to [illegible] auriferous deposits. Minor beds of arkose sand [illegible] the sediments of this series are usually characterized [illegible] flat-lying bedding or stratification.

Nipissing Diabase.—Doubtless some of the [illegible] diabase dikes and sill remnants intrusive through the Keewatin and Algoman rocks are the correlatives of the Nipissing diabase with which are genetically related the silver ores of Cobalt, Gowganda and elsewhere and hence is worthy of some [illegible]. A little Cobalt bloom was seen in a vein with a calcite gangue on the southwest shore of Radisson lake.

Pleistocene.—Superficial deposits of unconsolidated material cover a great part of the area. The drift deposits consist largely of sand, gravel, stratified clay, or sand and clay. The panning of some glacial sands and gravels in the area has resulted in a few colors of gold to the panfull. Since the sand and gravel is purely of glacial origin there is little chance of natural concentration having been effected to a sufficient extent to form deposits of economic importance.

Economic Geology

Speaking generally from an economic viewpoint the geological work proved disappointing, for much of the area is both overlain by swamps and sandy areas and underlain by hornblende granite. The Keewatin rocks near the margin of the granite batholith are [illegible] for prospecting.

Geologically the area is more favourable as a possible gold producer than for any other mineral. [illegible] discoveries have already been made at several widely distributed points in the area, viz., in Playfair, in Terry, in Egan and in Timmins townships.

Small deposits of fluorite have been found in Cairo and Alma townships in the eastern part of the Matachewan gold area. They occur in quartz veins in syenite. Since the syenite of the Watabeag area is thought to belong to the same batholith and owing to the widespread occurrence of fluorite in the area contiguous to the south, prospecting might be rewarded by the finding of economic deposits of this mineral. Small quantities of fluorite were seen in a quartz vein on the west shore of Radisson lake near the bay.

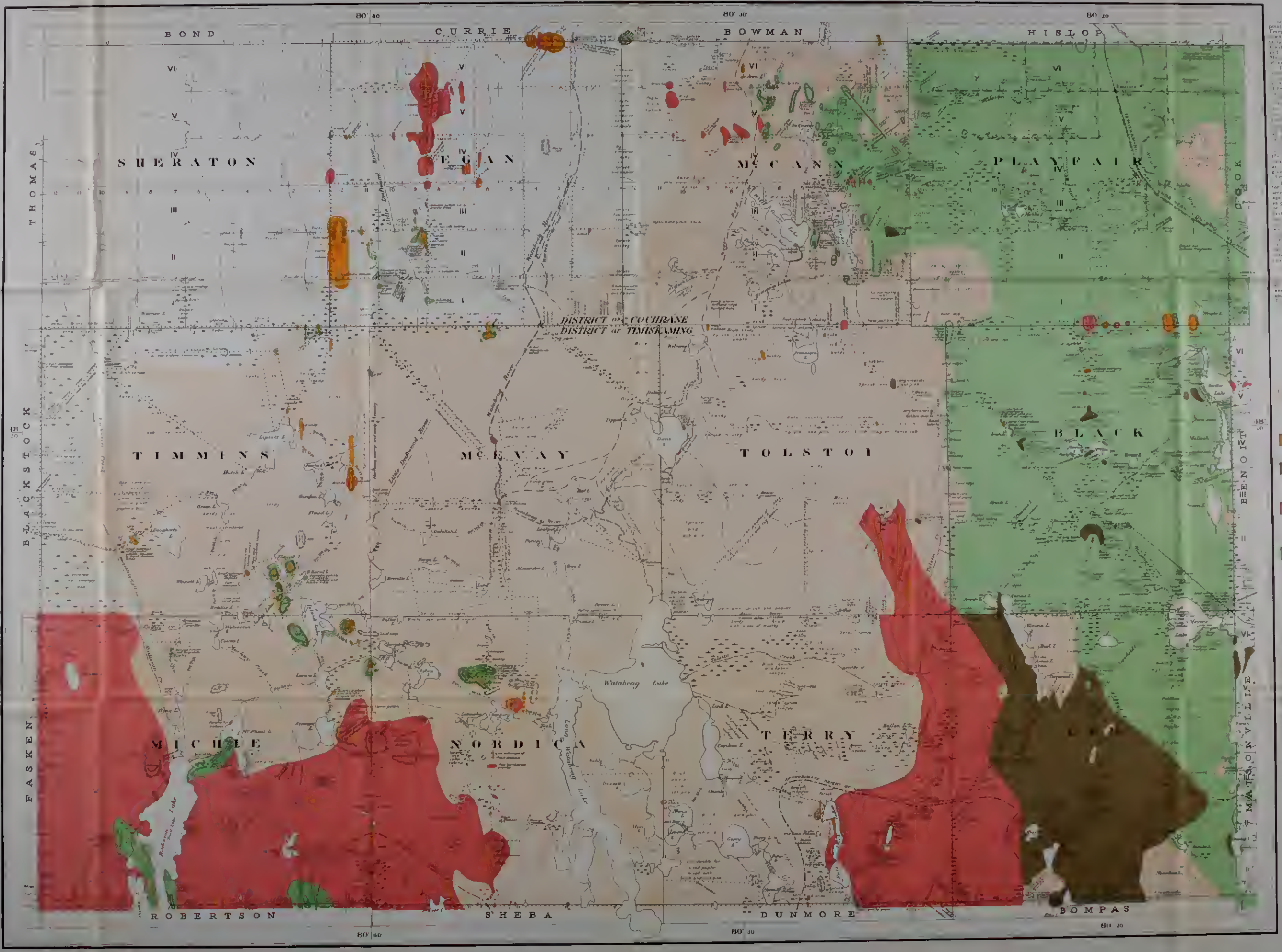
Barite veins of commercial importance have been found cutting the red syenite in one instance and the Cobalt series, slate and quartzite, in another, in the Matachewan area. There is a possibility of making similar discoveries in the Watabeag area.

Iron.—On the southern boundary of lot 12, concession II, Egan township, there is a small deposit of magnetite, with a minor quantity of chalcopyrite occurring as a magmatic differentiate from the post-Algoman diabase. Some of the chalcopyrite exposed to weathering conditions is altered to the blue basic cupric carbonate azurite. The outcrop at the point of concentration of the magnetic is quite small but the diabase appears to underlie the whole lot and appreciable local attraction was noted in this locality. It was, therefore, deemed advisable to mention this occurrence since differentiation from similar magma has in other areas yielded deposits of economic importance. Complementary dikes, further evidence of magmatic differentiation, were noted in the same locality. Several specimens taken from the outcrop were tested for chromium with negative results. Titanium is present.

Copper.—Copper bearing minerals, principally chalcopyrite, were observed in numerous localities throughout the area, but in no place was a deposit of sufficient extent seen to be of commercial value. In the area chalcopyrite occurs usually in a quartz gangue as small aggregates or minute disseminations throughout the fresh diabase or aplite dikes generally connected with the diabase.

Molybdenite.—Molybdenite was seen in a pegmatitic dike in the granite on the Breiderman claim, D. G. 47, on the south boundary of Terry township, and also on claim T.D.10 on the north boundary of Timmins township. The Timmins township occurrence is at the margin of a quartz vein 16 inches wide striking S. 60° W. and dipping 60° north. In both instances [illegible] the quantity of the mineral is small.

Erythrite (Cobalt Bloom).—Cobalt bloom was identified by the writer from a narrow calcite vein in proximity to the diabase dike which strikes in a northerly direction from the Radisson-Larose lake portage. The quantity was too small to be of economic importance but at the same time it points to calcite veins in the vicinity of the diabase dikes and sill remnants being worthy of attention as possible sources of silver. This mineral, cobalt bloom, has to date in the Province been found with Keweenawan (Nipissing) basic intrusions with which are also associated the silver, nickel and arsenic of Cobalt, and elsewhere in the Province.



Economic Geology

Gold.—Gold [illegible] have been [illegible] points in the area [illegible] Playfair [illegible] Terry townships. [illegible]

Synclinal or anticlinal structure would be deemed [illegible] an area for the [illegible] and north of an [illegible]. The usual trend [illegible]

LEGEND

Glacial and Recent

[illegible]

Sand and gravel

UNCONFORMITY

PRE CAMBRIAN

Keweenawan

🟧 Quartz diabase [illegible]

Cobalt series

🟫 Conglomerate, greywacke, argillite [illegible]

UNCONFORMITY

Algoman

🟥 Granite, [illegible] granite porphyry [illegible] and aplite and lamprophyre dikes

INTRUSIVE CONTACT

Keewatin

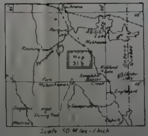
🟩 [illegible]

Symbols

[illegible]

Sources of Information

[illegible]



Scale 10 Miles = 1 inch

Map No 31d

WATABEAG AREA

DISTRICTS OF TIMISKAMING AND COCHRANE, ONTARIO

To accompany report by D. G. H. Wright in Volume XXXI, Part 7, Ontario Department of Mines Report, 1922

Scale [illegible] or 1 Mile = 1 Inch

Chains 80 [illegible] 1 2 3 Miles

5 weeks in

[illegible] Assembly

Gov. Doc. Ont.

Ontario. Legislative Assembly

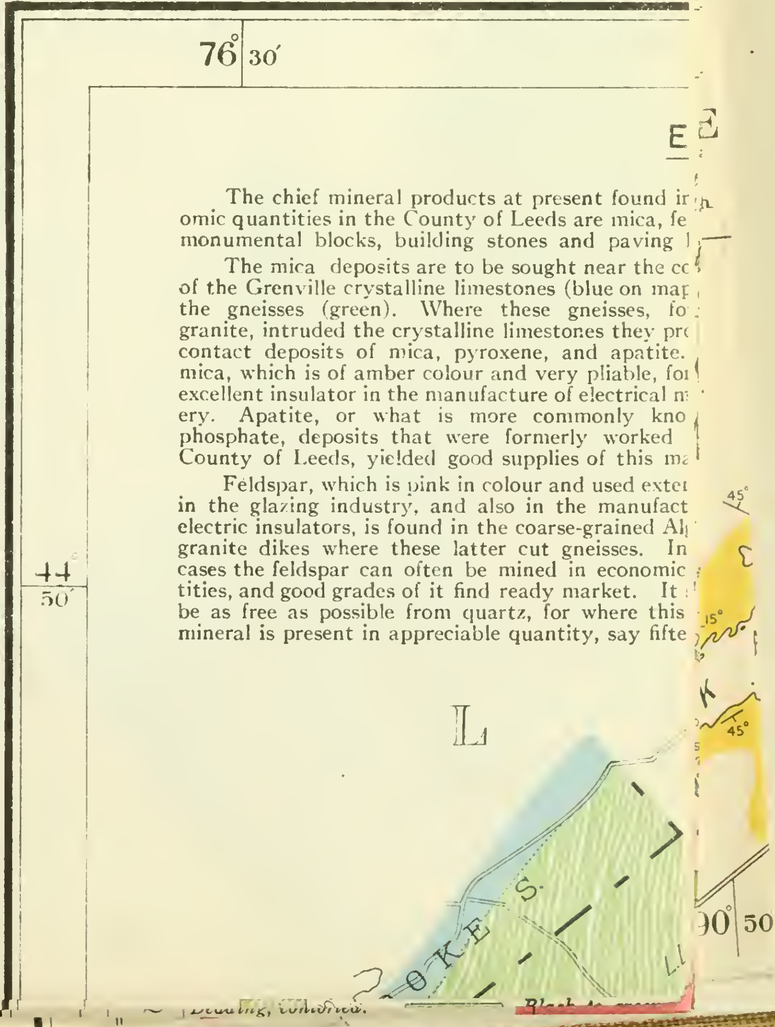
[illegible]

Gov. Doc. Ont. L

Ontario. Legislative Assembly
Sessional papers.
Vol. 54, pt. 2, 1922.

Map No. 31c.

COUNTY OF LEEDS



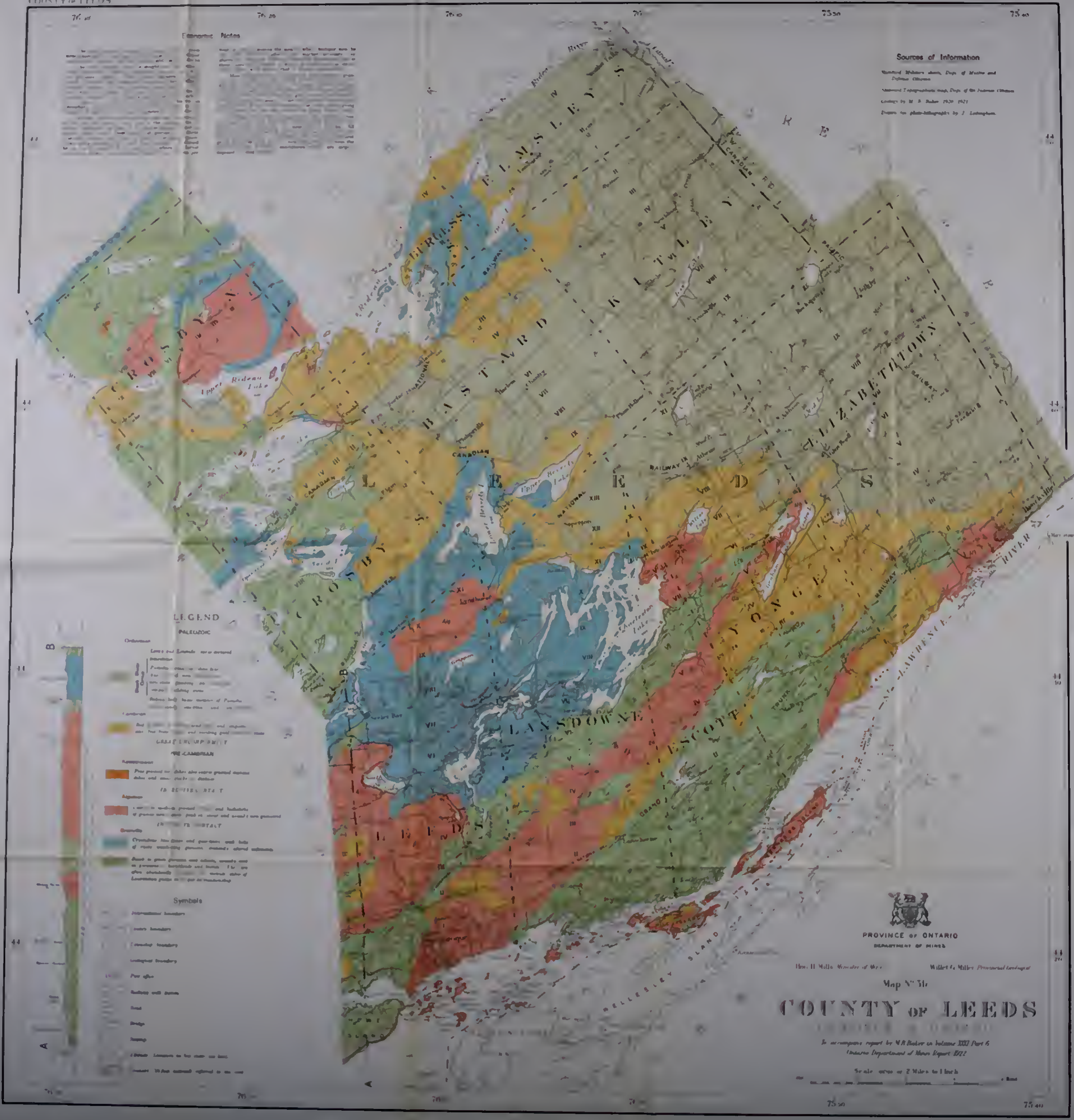
The chief mineral products at present found ir omic quantities in the County of Leeds are mica, fe monumental blocks, building stones and paving l

The mica deposits are to be sought near the cc of the Grenville crystalline limestones (blue on map the gneisses (green). Where these gneisses, fo granite, intruded the crystalline limestones they prc contact deposits of mica, pyroxene, and apatite. mica, which is of amber colour and very pliable, for excellent insulator in the manufacture of electrical m ery. Apatite, or what is more commonly kno phosphate, deposits that were formerly worked County of Leeds, yielded good supplies of this ma

Feldspar, which is pink in colour and used exte in the glazing industry, and also in the manufact electric insulators, is found in the coarse-grained Al granite dikes where these latter cut gneisses. In cases the feldspar can often be mined in economic tities, and good grades of it find ready market. It be as free as possible from quartz, for where this mineral is present in appreciable quantity, say fifte

Vol 54 pt 2 1922

Map No 3
COUNTY OF LEEDS



5 maps in

[illegible] Assembly

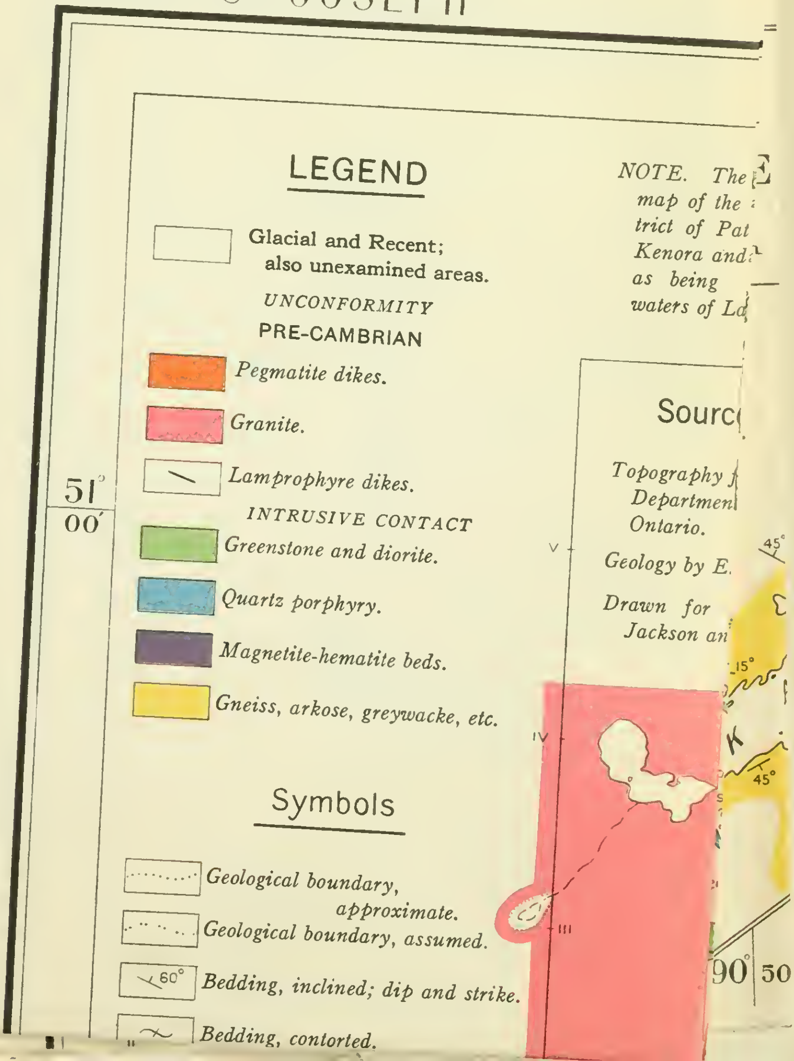
Gov. Doc.
Ont
L

Ontario. Legislative Assembly
Sessional papers
Vol. 54, pt. 2 1922

f

Map No 31e

LAKE ST JOSEPH



LEGEND

▭ Glacial and Recent; also unexamined areas.

UNCONFORMITY

PRE-CAMBRIAN

🟧 *Pegmatite dikes.*

🟥 *Granite.*

▭ *Lamprophyre dikes.*

INTRUSIVE CONTACT

🟩 *Greenstone and diorite.*

🟦 *Quartz porphyry.*

🟪 *Magnetite-hematite beds.*

🟨 *Gneiss, arkose, greywacke, etc.*

Symbols

Geological boundary, approximate.

Geological boundary, assumed.

Bedding, inclined; dip and strike.

Bedding, contorted.

NOTE. The
map of the
trict of Pat
Kenora and
as being
waters of La

Sourc

Topography f
Departmen
Ontario.

Geology by E.

Drawn for
Jackson an

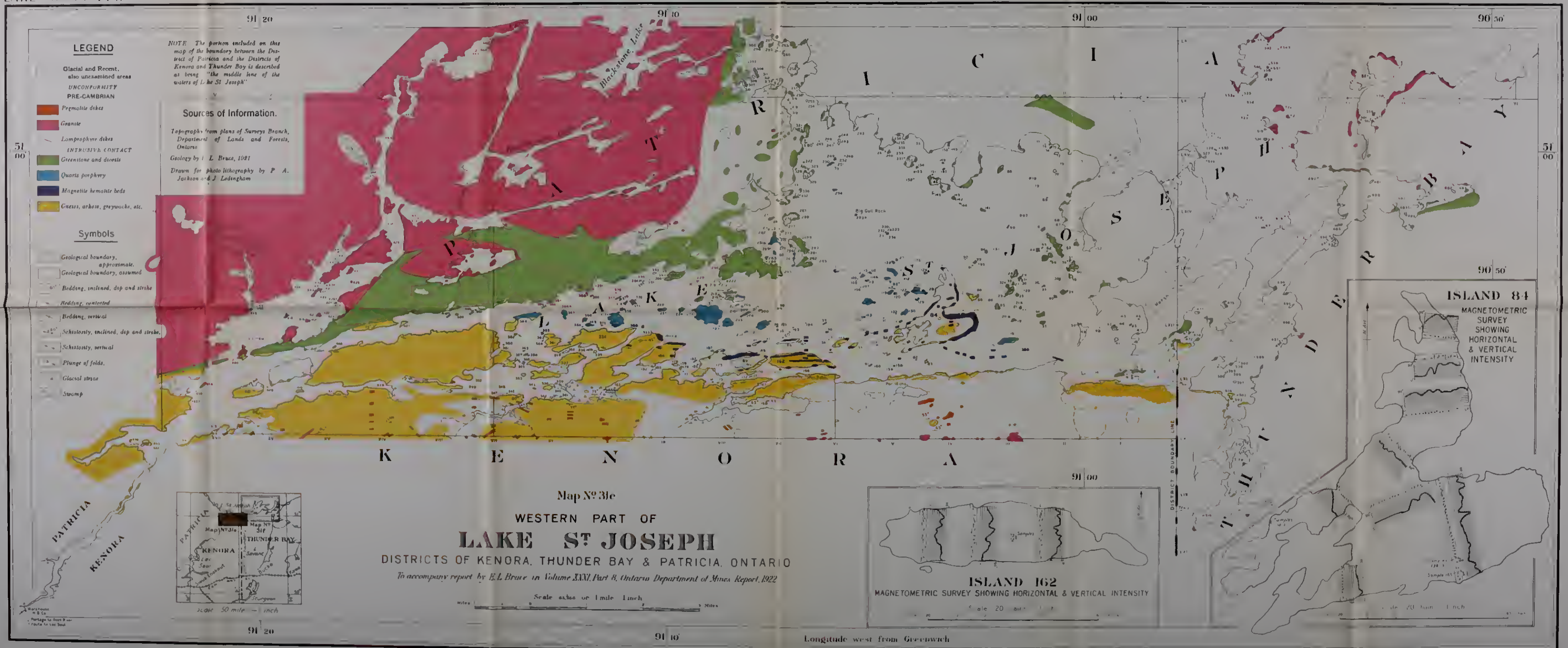
Gov. Doc.
Ont.
L

Ontario. Legislative Assembly
Sessional papers
Vol 54, pt 2 1922

PROVINCE OF ONTARIO
DEPARTMENT OF MINES

Hon. H Mills, *Minister of Mines*   Willet G Miller, *Provincial Geologist*

Map No 31e
LAKE ST JOSEPH



LEGEND

Glacial and Recent, also unexamined areas
UNCONFORMITY
PRE-CAMBRIAN
🟧 *Pegmatite dikes*
🟥 *Granite*
— *Lamprophyre dikes*
INTRUSIVE CONTACT
🟩 *Greenstone and diorite*
🟦 *Quartz porphyry*
🟪 *Magnetite hematite beds*
🟨 *Gneiss, arkose, greywacke, etc.*

Symbols

Geological boundary, approximate.
Geological boundary, assumed
Bedding, inclined, dip and strike
Bedding, contorted
Bedding, vertical
Schistosity, inclined, dip and strike.
Schistosity, vertical
Plunge of folds.
Glacial striae
Swamp

NOTE. The portion included on this map of the boundary between the District of Patricia and the Districts of Kenora and Thunder Bay is described as being "the middle line of the waters of Lake St Joseph"

Sources of Information.

Topography from plans of Surveys Branch, Department of Lands and Forests, Ontario

Geology by E. L. Bruce, 1921

Drawn for photo lithography by P. A. Jackson and J. Ledingham

Map No 31e

WESTERN PART OF
LAKE ST JOSEPH
DISTRICTS OF KENORA, THUNDER BAY & PATRICIA, ONTARIO

To accompany report by E. L. Bruce in Volume XXXI, Part 8, Ontario Department of Mines Report, 1922

Scale: miles or 1 mile = 1 inch

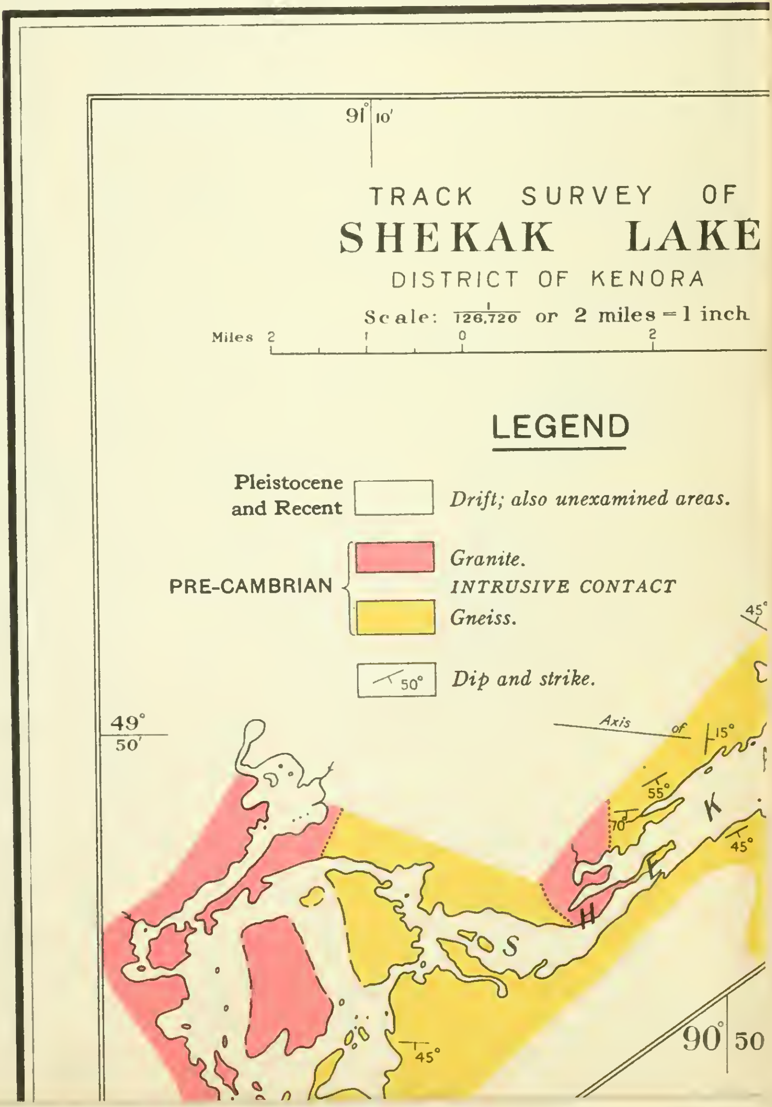
ISLAND 162
MAGNETOMETRIC SURVEY SHOWING HORIZONTAL & VERTICAL INTENSITY
Scale 20 feet = 1 inch

ISLAND 84
MAGNETOMETRIC SURVEY SHOWING HORIZONTAL & VERTICAL INTENSITY
Scale 20 feet = 1 inch

Gov.Doc.
Ont
L

Ontario. Legislative Assembly
Sessional papers.
Vol. 54, pt. 2. 1922

Map No. 31f
LAKE ST JOSEPH



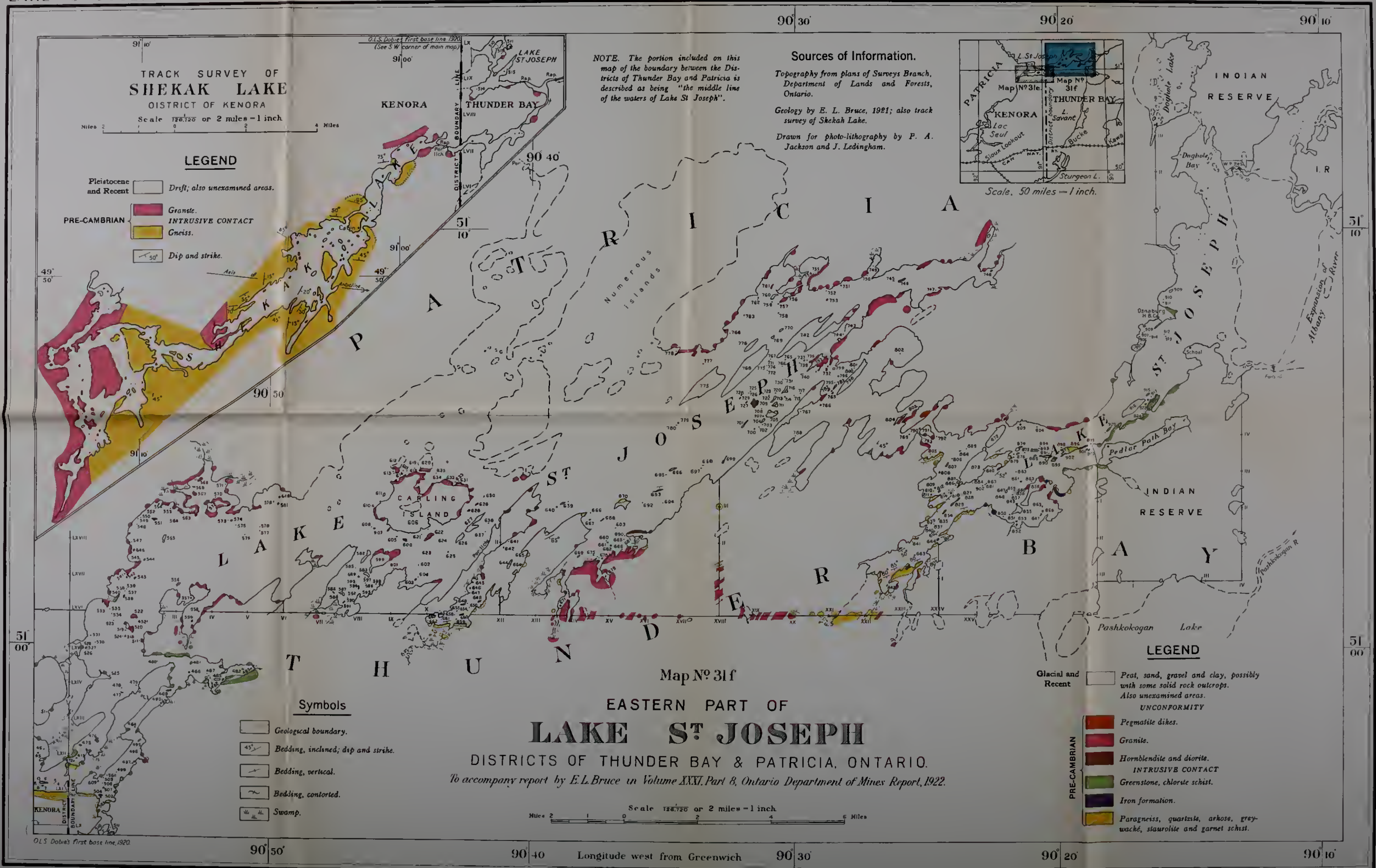
Gov. Doc.
Ont.
L

Ontario. Legislative Assembly
Sessional papers.
Vol. 54, pt. 2. 1922

PROVINCE OF ONTARIO
DEPARTMENT OF MINES

Hon. H. Mills, *Minister of Mines* **Willet G. Miller**, *Provincial Geologist*

Map No 31f
LAKE ST JOSEPH



Map No 31f

EASTERN PART OF

LAKE ST JOSEPH

DISTRICTS OF THUNDER BAY & PATRICIA, ONTARIO.

To accompany report by E. L. Bruce in Volume XXXI, Part 8, Ontario Department of Mines Report, 1922.

Scale 1/126,720 or 2 miles = 1 inch

NOTE. The portion included on this map of the boundary between the Districts of Thunder Bay and Patricia is described as being "the middle line of the waters of Lake St Joseph".

Sources of Information.

Topography from plans of Surveys Branch, Department of Lands and Forests, Ontario.

Geology by E. L. Bruce, 1921; also track survey of Shekah Lake.

Drawn for photo-lithography by P. A. Jackson and J. Ledingham.

LEGEND

Glacial and Recent: ☐ *Peat, sand, gravel and clay, possibly with some solid rock outcrops. Also unexamined areas.*

UNCONFORMITY

PRE-CAMBRIAN
- 🟥 *Pegmatite dikes.*
- 🟥 *Granite.*
- 🟫 *Hornblendite and diorite.*
- *INTRUSIVE CONTACT*
- 🟩 *Greenstone, chlorite schist.*
- 🟪 *Iron formation.*
- 🟨 *Paragneiss, quartzite, arkose, greywacké, staurolite and garnet schist.*

Symbols

- *Geological boundary.*
- *Bedding, inclined; dip and strike.*
- *Bedding, vertical.*
- *Bedding, contorted.*
- *Swamp.*

TRACK SURVEY OF
SHEKAK LAKE
DISTRICT OF KENORA
Scale 1/126,720 or 2 miles = 1 inch

LEGEND

Pleistocene and Recent: ☐ *Drift; also unexamined areas.*

PRE-CAMBRIAN
- 🟥 *Granite.*
- *INTRUSIVE CONTACT*
- 🟨 *Gneiss.*

Dip and strike.

5 maps in
pocket–

No. 31b.
No. 31c.
No. 31d.

Map No. 31e
Map No. 31f